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A Teaching Practicum in Physics

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A Teaching Practicum in Secondary Education: Physics

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To: John Goulet
This paper is dedicated to Drew Merrill and my first class of students, “The Scrubs,” for providing me with an unforgettable experience and hopefully the start of a long career in education.
Abstract

This paper is being prepared to discuss my experience as a Student Teacher in the subject area of Physics at Doherty Memorial High School in Worcester, Massachusetts. It will fulfill the requirements for a Massachusetts Department of Education teaching license as well as serve as the culmination of my Interactive Qualifying Project at Worcester Polytechnic Institute. It discusses the background and demographics of Doherty Memorial High School, how I was able to meet each of the Five Professional Standards for Teachers, my WPI education, and a view of the class I was teaching.
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Chapter 1: Background

The Massachusetts Education Reform Act of 1993 is a law passed by the state of Massachusetts in 1993 that completely changed the public education system of the state. The changes that were implemented over a seven year period included things such as increasing the budget for public schools, setting guidelines for course requirements, creating the MCAS standardized test, and more. Financially, the Act slowly increased the state’s budget for education from about $1.26 billion in 1993 to about $2.0 billion in 1997. The Reform Act also changed the curriculum greatly. Before the Act was put into place, the only requirements set in place by the state of Massachusetts were history and physical education. The Act extended the requirements to include math, science, English, foreign languages, health, and arts. Furthermore, the Act made it a requirement that all new teachers in the state of Massachusetts pass a test for both knowledge of their respective subject and their literacy and ability to communicate.

One additional change created by the Education Reform Act was the creation of the MCAS test. This is a standardized test that gets administered to every student in the 4th, 8th, and 10th grade in Massachusetts. This test serves many purposes, one of which being that students must pass the MCAS in the tenth grade in order to graduate. It is also used to measure the success of schools from year to year and against one another. By comparing the average test scores of students in a school from year to year, it is possible to determine if the school is improving or not. The scores can also point out if a school is lacking in one subject in particular if the scores are much lower than other subjects.¹

¹ Source:
users.wpi.edu/~goulet/teacher_prep/Overview%20of%20the%20Massachusetts%20Education%20Reform%20Act%20of%201993.doc
Compared against other states, Massachusetts is considered to be one of the best states in the nation in terms of education. *Education Week*, a magazine which does a yearly ranking of the 50 states and Washington D.C., ranked Massachusetts as the #2 state in the country. Massachusetts received a score of 84.1, just 3.4 points behind first place Maryland. To determine the scores, *Education Weekly* examines each state in six different categories and averages them together for a total score; the six categories are the Chance for Success Index; K-12 Achievement; School Finance; Standards, Assessments, and Accountability; Teaching Profession; and Transitions and Alignment.²

A more subject specific organization that measures education success is TIMSS, which stands for Trends in International Mathematics and Science Study. TIMSS assesses 4th and 8th grade students in Mathematics and Science every four years in almost 60 countries and nine specific states in the United States.³ This study is very useful for comparing a state’s performance against one another and for measuring a state’s growth from year to year. For Massachusetts, TIMSS in 2011, the most recent study, showed very promising results. One noteworthy result was that Massachusetts 8th graders showed more growth from 1999 than any other country or state in the entire study. Massachusetts 8th graders also scored the higher in math than any other state in the study and higher in science than every state but Minnesota, which they scored very similarly to.⁴

Each state has their own Curriculum Framework for every subject taught in public schools. The framework essentially plans out what topics are required to be covered for each

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² Source: [http://www.edweek.org/ew/articles/2013/01/10/16sos.h32.html?tkn=RLRF%2B4mUV1fjxGZAPk7Od%2FfW1p2K2SFHTAx9&cmp=clp-edweek&intc=EW-QC13-EWH](http://www.edweek.org/ew/articles/2013/01/10/16sos.h32.html?tkn=RLRF%2B4mUV1fjxGZAPk7Od%2FfW1p2K2SFHTAx9&cmp=clp-edweek&intc=EW-QC13-EWH)

³ Source: [http://nces.ed.gov/Timss/](http://nces.ed.gov/Timss/)

subject in every grade level. It is organized by broad categories such as Mathematics or Science, then get broken into more specific subjects like Physics, Anatomy, or Biology. The Curriculum Framework covers every subject from Kindergarten to twelfth grade. The premise for the Framework is that by the end of each course, a student should be able to comprehend each topic for the subject that has been outlined.\(^5\)

With each state having their own curriculum framework, there can be a lot of disparity between the standards and topics covered by a subject from state to state. In an effort to combat this discrepancy, the Common Core State Standards Initiative was created. This is an organization that is attempting to get every U.S. state and territory to follow the same curriculum, thus creating no inequality between states and ensuring that all students are equally prepared for college upon graduation. The Common Core is designed to provide teachers with a clear description of a curriculum that will maximize the efficiency of a public education, keeping students in the United States on level and competitive with other countries with high-ranking educational systems. As of now, 45 states, Washington D.C., and four U.S. territories have made the conversion to Common Core standards.\(^6\)

With Massachusetts being one of the states that converted to the Common Core standards, all public schools were required to make changes to their curriculums; Doherty Memorial High School is one of those schools. The Massachusetts Department of Education is remaking their Curriculum Framework, which will be adopted by Doherty in order to meet the requirements of Common Core. For Doherty Memorial High School to make the transition it will cost $42,295 for new curriculum materials for the middle and high school and another $72,274

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\(^5\) Source: [http://www.doe.mass.edu/frameworks/scitech/1006.pdf](http://www.doe.mass.edu/frameworks/scitech/1006.pdf)
\(^6\) Source: [http://www.corestandards.org/about-the-standards](http://www.corestandards.org/about-the-standards)
for teacher planning time, educator evaluation, and student success measurement tools. These changes don’t come cheap but will ensure that they are on the same track as every other school in the country.

As of the latest census, the city of Worcester had a population of 181,631 people. Being one of the 7 high schools located in Worcester, Doherty has a total student body of 1327 students. Of these students, 47% are Caucasian, 26% are Hispanic, 14% are African-American, 11% are Asian, 1% are American Indian, and 1% are listed as Unknown. This data is quite different from the demographics of the city of Worcester, with almost 70% being Caucasian and only 21% being Hispanic. Economically, Doherty Memorial High School has a relatively high poverty rate, with 42% of students being eligible for free lunch, compared to the Massachusetts average of 29%.

As stated earlier, every year all Massachusetts students in the 4th, 8th, and 10th grades are required to take the MCAS test. To examine Doherty Memorial High School’s success in the MCAS tests, their 10th grade 2012 average scores for each subject were compared against the Massachusetts average from that year:

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7 Source: [http://www.wickedlocal.com/reading/news/x1058231553/Proposed-school-budget-sees-4-7-percent-increase](http://www.wickedlocal.com/reading/news/x1058231553/Proposed-school-budget-sees-4-7-percent-increase)

8 Source: [http://www.publicschoolreview.com/school_ov/school_id/38870](http://www.publicschoolreview.com/school_ov/school_id/38870)

9 Source: [http://quickfacts.census.gov/qfd/states/25/2582000.html](http://quickfacts.census.gov/qfd/states/25/2582000.html)
As the graphs clearly show, Doherty is slightly less than average for a Massachusetts high school. Mathematics is arguably their strongest subject, as 48% of students scored in the “Advanced” level, however, in science they managed to be higher than the Massachusetts average for students scoring “Proficient.”

One constant hurdle in the teaching profession is helping English Language Learners (ELLs) keep pace with the rest of the students. By definition, an English Language Learner is a student whose first language is something other than English and who is unable to perform schoolwork in English.11 This can prove difficult for teachers because they must teach these students at the normal pace while overcoming a language barrier. In Massachusetts, one attempt to overcome this barrier is the Sheltered English Immersion (SEI) program. This is essentially a style of teaching that teachers use in a classroom with ELLs to help them understand the lesson despite having difficulties speaking the English language. The basic premise of the SEI is the use of visual aids and physical actions to help ELLs associate words they aren’t familiar with, with


something visual.¹² This way, a similar visual can be presented on a test or evaluation and the student should be able to understand the problem at hand.

¹² Source: http://www.hps.holyoke.ma.us/ell_glossary.htm
Chapter 2: Plans Curriculum and Instruction

The first of the five professional standards for teachers is that of “Plans Curriculum and Instruction.” In a broad sense, this standard involves making sure that every topic is covered in the given time and that each topic is broken down into individual planned lessons including labs, activities, and out-of-the-classroom work. A great deal of planning is required to ensure this is accomplished. First the entire year must be broken down by unit, then each unit by lesson. This is not a static plan, however, as unexpected occurrences can require the plan to be changed from time to time.

2.1 Curriculum Planning

Being involved in an Advanced Placement class, the curriculum could be followed slightly differently than if it were a traditional college-preparatory course. Rather than basing the curriculum on the standards provided by the state of Massachusetts, the topics that needed to be taught were dictated by the material that was included on the AP exam. The order in which topics were covered could be rearranged slightly, and in some cases some topics could be eliminated completely.

The goal of an AP course is to enable the students to receive the highest possible grade on the AP test that is given each year. Therefore, some strategy is required when it comes to planning the curriculum. At the start of the year, Drew Merrill and I planned out a rough timeline of how the topics were going to be taught. This plan allowed for every topic to be covered in the allotted time before the AP exam, but we knew that it was very unlikely that this timeline would be followed perfectly. As we went through the course, we realized that some topics required more time than anticipated for the class to gain a proper understanding of the material. Since the date of the exam doesn’t change, some adjustments needed to be made to our planned curriculum. This left us with two options: to shorten other topics or eliminate some completely.
When trying to decide how to make up for lost time, I consulted John Staley, the Science Department Head at Doherty Memorial High School. His recommendation was to simply eliminate the topics that didn’t hold as much weight on the AP exam. To determine which topics would be best to eliminate he referred me to www.collegeboard.org, where the AP exam was broken down by subject, including the percentage of the test that each topic took up. The breakdown of the exam can be found in Appendix A. His logic was that it was more effective to make sure the students completely understood most topics than for them to partially understand every topic. I agreed with this logic and applied it to my class.

An example of this comes from the Newtonian Mechanics portion of the class. It took a bit longer than expected to cover the unit on Newton’s Laws of Motion. This section, however, accounts for 9% of the AP Physics B exam so it would be a great hindrance to the students if they had a less-than-complete understanding of the material. To make up for the extra time that was spent on the forces unit, we eliminated the section on harmonic motion and oscillations. That with universal gravity accounts for 6% of the exam so by eliminating harmonic motion and oscillations, we probably only skipped 3-4% of the material. This was a beneficial move because the unit of Newton’s Laws is so crucial to the overall exam. By skipping past topics that are not large parts of the test, it allows for a very thorough coverage of the topics that provide an opportunity for more points to be earned, ultimately leading to higher scores.

2.2 Lesson Plans

Once the overall curriculum for the year is planned, each unit must be broken down into individual lesson plans. To do this, Drew Merrill and I sat down at the beginning of each week and set a timeline of what the week would entail. We would plan out when we would cover each topic, what labs we would do, when tests and quizzes would be, etc. I would then proceed to make the lesson plans for the week and let him look over them for approval. Each lesson plan
contained the topic of the day, the objective, the development of the lesson, and the homework assignment. Some of the lesson plans I created can be seen in Appendix B.

The objective of each lesson plan was the purpose that was set for each day, worded in a way that it could be confirmed or denied if it was met. The objectives were always written in the format of “Students will be able to (SWBAT)…” followed by a skill such as “calculate the force of friction necessary to keep a box from sliding down an inclined plane.” This is a measurable objective; either the students can calculate it and are ready for independent practice, or they cannot and need more help on it. The objective was never worded in a way such as “Students will understand…” because it is impossible to physically measure someone’s understanding.

After the objective, the lesson plan contained the development of the lesson. This basically outlined the order in which the lesson would be delivered, with notes and reminders to myself of what to cover. In the beginning it also contained some sample questions that I could assign to the class for them to work on either independently or in a group. This later changed, as will be demonstrated in the upcoming section about teaching methods.

Finally, the lesson plan for the day contained the homework assignment, if any, that was to be completed for the following day. It usually contained 2-5 problems that revolved around the lesson that was taught that day, but sometimes covered older material that the students needed a refresher on.

2.3 Teaching Styles

When I first began teaching the class, every lesson was delivered on the whiteboard, with all new information and practice questions being written out by hand. After the second unit, however, I began to sense that the students weren’t finding the use of the board to be very beneficial. To determine if I was correct in thinking this, I had each student anonymously write on a piece of paper what they would like to see changed in the class. As expected, most students
felt that some time was wasted by hand-writing everything on the board and that sometimes it was hard to read. This is when I transitioned from using the board to basing the lessons off of a PowerPoint presentation that I would make for each unit. These PowerPoint slides can be seen in Appendix C. The entire lesson was not included within the slides, but useful equations, practice problems, pictures, and diagrams would be included so that they could be brought up instantly and clearly. An in depth analysis of how a lesson with PowerPoint slides went can be seen in Chapter 3.
Chapter 3: Delivers Effective Instruction

The second of the five professional standards for teachers is that of “Delivers Effective Instruction.” As the name implies, the main goal of this standard is to deliver each lesson, test, and assignment in a way that the students effectively learn from. There are numerous ways to do this, mostly concerning the method by which the lesson is delivered to the students, but also including the activities/labs that the students performed, homework that was assigned, and the availability of the teacher to the students to help explain areas that the students were having difficulties with.

3.1 Objectives

When delivering a lesson, it is important that the students know specifically what the goal of each lesson is. This is generally referred to as the “objective.” As mentioned in Chapter 2, the lesson plan for every day started off with the objective for the lesson, written in the form of “Students will be able to…. This is good for me to know, as the instructor, so I have something to hold me to when planning the lesson, but it is also important that the students also know the daily objective. If a lesson were to be carried out without ever telling the students what the objective of the lesson was, they may finish the day with a large amount of information, but with no concept of how it applies to the overall subject matter. This can come into play during tests, also, because a student may encounter a problem that they have the knowledge of how to complete it, but they may not know how to apply what they know directly to that situation. The objective for each lesson can act as a trigger in the students’ minds so that when they encounter a problem and see what it is asking for, it reminds them of an objective that they learned, thus allowing them to tap into the skills they learned that day.

To ensure that the students knew what the objective for each lesson was, every single day started with the writing of the date and objective in the top right corner of the whiteboard. It
stayed there for the entire class so they could always look there and remind themselves of what
the objective was. I also started each class with a basic agenda of how the lesson was going to be
carried out so that the students knew the way in which the objective would be fulfilled. This way,
even if something didn’t make sense at first, they knew that there would be a portion of the
lesson following it that would help to further explain the issue they were encountering.

3.2 Delivery of the Lesson

3.2.1. Homework

There are two components of physics that are critical to the students to enable them to
learn effectively: individual practice and understanding the previous material. Individual practice
is easily provided to the students in the form of homework. Almost every night, therefore,
homework assignments were given to the students consisting of anywhere from 2-5 problems out
of their textbook, based on the material covered in that day’s class and the classes preceding it.
The students were required to go home and complete the assignment so that it was done and
ready by the start of the next class. The homework was almost always collected and graded with
the vast majority of the grade being weighted towards effort. The days that it was not collected
were the days that the students showed they were lacking a comprehension of the material that
was assigned. In this case, more time would be spent in that day’s class covering the confusing
material and the students had the practice problems to go back over individually.

Individual practice on new material is an effective way of getting the students used to
applying the methods they learned, but it is only effective if they are using the correct method to
complete each problem. If they were to practice the wrong methods of solving a problem and
never learned they were doing something incorrectly, they would never get a correct
understanding of how to actually perform a problem, especially on a test. To ensure that the
students were using proper methods, every class after homework was assigned started with
myself asking the students which problems in particular they had difficulties with. Sometimes the majority of students would respond with one particular problem, and other times a wide range of questions would be asked about. I would then ask where, specifically, in the problem they had difficulties so that I could hone in on a particular concept that the group as a whole was struggling with. Oftentimes, to conserve the amount of time spent covering old material, the homework review would be reduced to explaining specific concepts rather than solving the whole problem in its entirety, then a similar problem would be assigned on the next night’s homework. By doing this, I was able to get a firm grasp on how effective the delivery of the previous lesson was so that I knew if the students were efficient at applying it or if I needed to spend more time teaching it to them.

3.2.2 Lecture Format

As mentioned earlier, when I first began teaching, every lesson was provided in the form of me writing down every piece of information they needed to know on the whiteboard and the students copying it down into their notebooks. Through a class survey, however, I found that this particular method was not working very well for the students and that a new method needed to be implemented. This is when I began utilizing PowerPoint presentations. During my time in the Teaching Methods class with John Staley and Renah Razzaq, they warned us of the dangers of PowerPoint and how it can cause students to lose focus in the lesson if everything is being provided to them from a projector. This caused me to combine the best qualities of both the PowerPoint presentation and the whiteboard.

These PowerPoints, which can be seen in Appendix C, were created in a way that they did not contain all the information that was vital to the understanding of the lesson. This forced the students to pay attention rather than mindlessly writing down everything they saw on the projector screen, otherwise they would miss an important part of the lesson. The PowerPoint
slides usually contained background information on the topic that was being covered, as well as the corresponding equations that would be used in solving relevant problems. These equations were not always provided right away, however. Sometimes they would make more sense if the students could actually see the origin of such equations, so these derivations were always provided step-by-step on the whiteboard. By doing this, the students could base their learning of a new formula on a topic they had already mastered rather than simply seeing a relationship of new variables.

Once the providing of new information on a particular topic was finished, it was time for the students to apply what they learned in the form of practice problems. These problems were provided on the PowerPoint slides so that time was not wasted writing them out by hand. Once the problem was read aloud to the students and any questions about it were answered, the students formed groups of two to three to work on the problem as a group. My rationale behind the group work was that they would be getting enough individual practice that night in the form of homework, so it might be more effective if a collaboration of their peers produced the correct methodology towards answering a practice problem. Often students would help remind one another of a particular step that they were forgetting, thus making them realize the correct way to answer a problem at the beginning, rather than learning it incorrectly due to a simple mistake and having to relearn it later.

As the students worked in their groups, I would slowly make my way around the room taking a look at the students were doing. At first, I would remain mostly quiet, only speaking to explain questions in understanding what the problem was asking for; I wanted the students to work their way through it on their own. As time progressed, however, I would point out mistakes that were made that the students did not catch on their own, as well as providing hints on how to
complete a certain step that was giving them trouble. I wouldn’t flat-out tell the students the correct way to do something, but rather ask them questions about what they remember from the lesson so they could figure out themselves what needed to be done. I believed they were more likely to remember something if they figured it out themselves rather than having me just lay out the steps for them.

Once the class as a whole was getting close to finishing the problem, I would reveal the answer on the PowerPoint. This would give the students who finished the problem first to determine if they had arrived at the correct answer so they could go back and check the work they had done. It also saved me the time of having to check every group’s answer individually, giving me more time to work with the groups that were struggling. At first, students didn’t like this, as they felt the problem was pointless if the answer was given to them at the end no matter what, but I quickly convinced them of how unimportant the answer actually is. My main goal with practice problems was to ensure that the students knew the correct method to solving each type of problem they could encounter on a test or the AP Exam. I explained to them that on the AP Exam, for a 10 point problem, the correct answer was only worth one of those ten points. The remainder of the points came from displaying the correct steps and methods towards finding an answer. To enforce this, I insisted that every time the students attempted to complete a problem, they show every single step necessary to do so, no matter how mundane. This got them in the mindset of always being thorough both to prevent simple mistakes, but also to ensure they receive full credit for the work they do on the AP Exam.

3.2.3 Informal Assessments

One teaching method that was taught to me by John Staley and Renah Razzaq in my Teaching Styles and Methods class that I found to be particularly useful was that of informal assessments. These were performed at the end of many lectures and consisted of me asking
generic questions about the material that was learned that day. I often implemented the method of peppering and cold-calling in which I would ask the questions rapid-fire to any student in the class, not necessarily ones that were raising their hands. This allowed me to get a quick understanding of how well the material from that day was learned.

3.3 Labs

One thing that I always find very beneficial when learning a new subject is the way by which it can be applied to the real world. I made sure that my students were exposed to the same real-world applications that I found to be helpful. This was accomplished mostly in the form of labs. My goal was to have at least one major lab and a few smaller labs take place during every unit that we covered. Due to the supplies that were available at Doherty, some units contained much more labs than others. Thermodynamics, for example, was a very difficult unit to create a lab experiment for. Nonetheless, the labs required the students to take the knowledge and equations that they had learned in the current unit and apply them to actually making something happen in the real world.

To make students more engaged in the lab activities they were performing, the experiments were often presented in the form of a challenge. One particular lab that was received exceptionally well by the students was the Teenage Mutant Ninja Turtle Bungee Jumping lab. This lab took place during the Energy unit. Every group of students was given time to take measurements of a toy turtle that was being used for the lab. Each group was then given a length of string and as many rubber bands as they needed. Their goal was to use the conservation of energy to calculate the number of rubber bands that should be tied between the turtle and the string so that when dropped from the top of the staircase, the turtle’s head would come as close to possible to the ground. The team that got the turtle the closest to the ground without hitting it would be crowned the champions. Upon learning of this challenge, the students immediately got
very excited to start making the calculations and every group was working diligently and passionately to figure out a way to win the competition. It seemed like they had almost forgotten they were doing physics calculations, but were rather playing a game with their friends. By taking a real-world thrill sport like bungee jumping and combining it with a friendly competition against their peers, the students were enthusiastic and excitedly performing advanced physics calculations, ultimately giving them a better understanding of the topic they were learning. This lab can be found in Appendix D.

3.4 Exams

As is common amongst teachers, I concluded each unit with a summative exam of every topic that was covered. This enabled me to get an idea of how well the students as a whole understood the material that was presented to them. Most individual test scores were generally a reflection of the amount of effort that the student put in over the course of the unit, and the class average tended to shift depending on the difficulty of the material being taught. The exams can be found in Appendix E and the gradebooks that include the students’ grades can be found in Appendix F.

When I was creating the exams, I had two goals in mind: creating an accurate representation of the material that was taught in that particular unit, and providing preparation for the AP exam. To do this, I used the format that the students could expect to see when taking the AP exam at the end of the year. The exam always has a large number of multiple choice questions followed by a few open ended questions in which partial credit was attainable. When grading, I always awarded the majority of the points based on the correct solving method of the problem and only gave one point for the actual correct answer.

As a side note, it can be seen that each exam had an “extra credit” question that appears to have nothing to do with the material on the exam. This is because the students consistently
asked me for extra credit questions, but I did not want to give any because there will be no such question on the AP exam. Therefore, on each test I gave a nearly impossible extra credit question that no one would be able to answer correctly, but would lighten the overall mood of the exam and keep everyone relaxed.

3.4 Grades

Teaching styles, assessments, and activities all can provide great insight into the methods by which effective instruction was delivered, but the main indicator of sufficiency in this area is the concrete data in the form of grades. A breakdown of each student’s grades can be seen in Appendix F and the final grades for Quarter 1, the only quarter I was there for in its entirety, can be seen in Appendix G. The most notable result from these final grades is that every student in the AP Physics class earned a grade of a C or higher. Specifically, six students earned an A, three students earned a B, and three students earned a C. It is to be expected that some students will outperform others, so is natural to see the grades spread out across the letter ranges from A to C, but the most impressive result from this data is that every student was in the passing range and that half of the students managed to achieve an A. The class average for quarter one came out to be 84.83 which can be considered to be more than satisfactory. The distribution of the quarter 1 grades is shown below with a bell curve plotted with the frequency of each final grade. All but two data points fall underneath the curve.
Bell Curve of Quarter 1 Grades
Chapter 4: Manages Classroom Climate and Operation

In order for a class to be successful, it is crucial to have a learning environment that enables them to do so. This includes things such as the mindset of the people in the room, the physical classroom makeup and supplies, and the general flow of activities. If all of these things are satisfactory, it will make an effective delivery of lessons much easier.

4.1 Classroom Atmosphere

It is of my personal belief that for students to be effective in a class that they should enjoy actually being there. This is something that I tried to implement as frequently as possible during my time as a teacher. When a student actually looks forward to showing up to class, he/she is much more likely to respond positively to work that is being assigned to them. That is why I tried to make the general atmosphere of the classroom a very pleasant and inviting one so that students would have some fun while they were being productive.

There were many ways in which this was accomplished. The first step was making sure that all the students felt comfortable in class. From personal experience I can testify that a teacher will sometimes try to make a joke of some sort and the students will either not respond or feel slightly awkward laughing because they are not comfortable enough with the teacher to know how to respond. To make sure that the students would be accepting of the light-hearted atmosphere, I got to know the students on a personal level before attempting to be humorous or do a fun activity. That way, once everyone was accepting of me as a peer as well as their teacher, they would respond well to any jokes or funny remarks. An example of this is when I began to use PowerPoints in class, I told the students that I had never actually made a PowerPoint before, which was true. From that point on, they always found it funny when I discovered a new effect and I poked fun at my lack of ability to create extravagant slides. I also let the students critique
my slides as a way of bringing me down to their level in a sense. I always made sure that the jokes were directed at me rather than at other students to ensure that no feelings were ever hurt.

One of the main jokes in the class was that I was very much against giving extra credit. They would always ask me for extra credit questions or assignments, knowing that I very seldom actually assigned them. On the tests, as mentioned earlier, I would ask near impossible questions for extra credit with the sole intention of making the students laugh and relax a little during the high-stress situation of a test. I also assigned many activities that were in the form of a competition amongst the students in the class. They would always ask what the prize was for the winner, hoping that it would be extra credit points, and my response would be that it was the satisfaction of winning and knowing they mastered a new topic. They would pretend to get frustrated, even though they knew what my answer would be, furthering the running joke in the class.

Another way to promote fun in the class was to assign activities and labs that the students would enjoy doing. An example of this is the Ninja Turtle Bungee Jump lab that was described in Chapter 3. The students were able to get the pleasure of throwing a toy off of a staircase while applying the physics of the situation at the same time. The lab was also done in the form of the competition which always gets students engaged due to the hopes that they can win. Another activity that the students seemed to enjoy was one where they would run up a flight of stairs as fast as they could and calculate how powerful they were based on their mass and how long it took change their elevation. Anytime the students had the opportunity to apply the material to the real world, they had a good time doing so.

The students also found the use of videos to be very entertaining and a good way to break up the class. I would often show videos of extreme sports to grasp their attention and to analyze
how it related to physics. Another fun, but effective way to implement the lessons that were being taught was to show videos of the Road Runner and Wile E. Coyote cartoon. These videos contained many different traps set up by Wile E. to catch the Road Runner that were physically impossible. I would show the students a clip of the cartoon, which always provided a laugh, and then had them analyze what physical laws were being broken and why the things in the video could never actually happen. The students greatly enjoyed this and were constantly asking me if I had any cartoon videos that applied to the material they were learning.

While having fun is good for the classroom environment, it was always important to maintain a balance of fun and seriousness. By allowing the students to enjoy themselves in the classroom, it was not uncommon for everyone to get unfocused and rambunctious. At these times, it was necessary to remind the students that the main priority always had to be learning, and that if they could enjoy themselves in doing so, it was fine, but once productiveness began to decrease, it was time to focus and get their work done. Students generally responded very well to this as a sign of respect. They realized in order to get the privilege to do things they liked doing, there needed to be times when they buckled down and did their work. This give-and-take system allowed for a good balance of enjoyment and effectiveness.

4.2 Physical Environment

In order to have an effective learning environment, it is very important for the room to have the necessary supplies for lessons to be delivered. One of the main aspects of this is laboratory materials. Being a science course, there are many laboratory activities that help students apply the material they are learning to the real world. Unfortunately, Doherty Memorial had a fairly low budget for lab materials, but we were still able to be effective with what we had. Sometimes, Mr. Merrill and I were able to create a lab activity using things that we had at our houses. One example of this is when the students were doing a conservation of energy
and circular motion lab and the goal was to drop an object from a certain height so it followed a track and went around a loop. To create this, Mr. Merrill brought in a Hot Wheels car track that belonged to his daughter for the students to use. Most physics labs don’t require high-technology equipment, but rather an everyday object of which the physical concepts could be analyzed.

Another physical entity that ended up being crucial was multiple whiteboards. In order to get multiple students involved at once, I would often call on several people to come up to the boards in the room and write out their process for solving the practice problem that the class was working on. If our classroom only had one whiteboard or if the board was very small, it would have been impossible to get as many students involved at one time, thus inhibiting those students who were very eager to volunteer.

4.3 Behavior

One of the main challenges in ensuring that lessons get delivered effectively is making sure that everyone is behaving. When a student is not focusing or is talking to their neighbors, they often prevent several students from learning, not just themselves. There were some instances when a student would be talking to the person sitting next to them and that person had no interest in holding a conversation. In cases like this, the student who is trying to pay attention to what is being taught is affected, without even being the one who made a decision not to focus. Therefore, it was necessary that good behavior be mandated at all times.

Being a class of only 12 students, it was fairly easy to identify if a particular student was talking or doing some other distracting action. A quick survey of the room enabled me to identify if any students were doing something other than taking notes or working on the practice problem that had been assigned. Forcing these students to go back to their work, however, was another challenge entirely. The vast majority of students were respectful and never had any bad intentions, but all students get distracted or feel lazy from time to time. These students were
fairly easy to handle, as a simple reminder to stay on task usually got them back into a school mindset.

One student in particular, however, became very apathetic towards doing any work as the year went on. He was much more challenging to control. I tried to be very stern with him, but he tended to simply ignore these reprimands and continued to do whatever he wanted. I then was forced to threaten him with disciplinary actions, including taking away points from his grade, as class participation was as factor. Being an Advanced Placement class, all the students were motivated and concerned about their grades, so this tended to have a better effect on the student. At other times, it was necessary to isolate him so that his distractive behaviors would not affect the other students in the class that were actually trying to get work done.

4.4 Transitions

From my observations, I found that when students had a lot of work to do and the class period was filled with material and activities, they generally stayed on-task better than when there was a lot of down-time. This made me realize very quickly that in order to maximize efficiency, I had to minimize periods of little or no activity. One of the main causes of these slow periods was slow transitions from one part of class to another. For example, when I was delivering lessons on the board and it came time for a practice problem, the students would start holding conversations while I was writing out the problem on the board. It then would take some time to get everyone to be quiet again and get back to doing work. To eliminate this writing time, I switched over to delivering the lessons using PowerPoint. That way, the practice problems that I was assigning to the class would already be prewritten when class started. All I had to do was click to the next slide and the question that the students were to work on would show up. By creating smooth transitions like this, it greatly reduced the periods of low activity that could cause students to get sidetracked.
Chapter 5: Promotes Equity

The fourth professional standard for teachers is that of “Promotes Equity.” This standard incorporates many different things, as equity can be created in several different ways. Equity must be promoted between native- and non-native-English speakers, between students of all motivation levels, and between students of all different personal situations. Every student is completely different and learns differently than everyone else, but it is crucial that everyone gets the same opportunity to learn.

5.1 English-language barrier

One of the largest obstacles to overcome is that of a language barrier. This problem is especially prevalent in a school like Doherty where there is a very diverse population. Many times, a student who has the potential to excel at a subject does poorly, not as a result of a lack of knowledge, but because of a difficulty in understanding what is being taught or asked. An English-language-learner (ELL) has the added challenge of first comprehending what the question is asking before answering it, whereas a native-English speaker can complete the comprehension phase with ease. These students, however, deserve the same opportunity to get an education that utilizes their full potential as a non-ELL.

There are many ways in which I attempted to promote equity between ELL students and native-English speakers. In my class, there were three students from Iraq, each of which had a different level of English-speaking ability; one could speak English almost as well as anyone else in the room, whereas another had very little comprehension of the English language. The main thing that I found helped these students understand the practice problems was to keep everything as vague as possible and to keep things consistent. I learned this when I asked a question about a baseball bat hitting a baseball and one of the students came up and asked me what a baseball was. I had assumed that this was common knowledge, but I was not taking into account that this
may not be a popular sport in other cultures. To combat this problem, I transitioned to not using specific items in a practice problem but rather saying things like “a box is resting on a ramp….,” Whenever possible, I made sure that the object in the question was either a box or a ball, depending on the scenario. Then, even if a student didn’t originally know what these objects are, once they learned, they wouldn’t be forced to figure out what was going on in every new question. I also made sure that these generic objects were always used on the tests, that way the ELL students wouldn’t have to decipher any new words on the test, making them as efficient as possible.

When helping the ELL students to understand a problem, I had to be cautious of making sure that I was giving the other students the proper amount of assistance, too. I often found myself spending a lot of time helping the ELL students understand the practice problem the class was working on, thus ignoring the other students who had questions about how to solve the problem. I soon found that the use of small groups allowed for assistance to be given on both ends. By pairing up the ELL with the least English skills with the ELL that had the best English skills, I could have the latter help explain the problem while I went to help out the other students. On the flipside, students that were native-English speakers could help each other solve the problem while I was spending time explaining what the problem was asking to the ELL students. By doing this, assistance could be given at all times, no matter where I was and what I was doing.

5.2 Motivation Levels

Another problem that I encountered was that of promoting equity between people of all motivation levels, both overly low and overly high. On one hand, I couldn’t let a student with low motivation fall behind because he/she didn’t want to do anything, but on the other hand I
couldn’t ignore some students just because one student wanted to answer every question. This created a difficult task of trying to get everyone equally involved in what was going on in class.

5.2.1 Low Motivation

For the most part, low motivation was not a huge problem. Being in an AP class, the majority of students were there because they were highly motivated individuals that chose to be in an advanced class. There was one student, however, that lost his motivation throughout the year to the point where he was refusing to do any work. The reasons for this will be analyzed further in Chapter 8, but the problem was making sure that he didn’t fall behind the rest of the students despite his best efforts to do so. This was difficult to do because of his defiance to do any work, but it needed to be done. Initially, I began by staying on his case constantly whenever work was assigned to the class, but as soon as I turned my back to work with other students, he would put his head down and do nothing again. This was frustrating because at the beginning of the year he demonstrated that he had the capability to be very successful and do the work well. My next move was reminding him that points could be taken away from his grade if he didn’t do any classwork or homework, but this was ineffective as he clearly was not concerned with earning a high grade. What it ultimately resulted in was assigning group work so that students could help each other and I sitting down with him one-on-one and forcing him to do what was assigned. Occasionally I would leave to answer a question quickly, but I would come right back to him and continue pushing him along with the problem. He always ended up getting the correct answer when he tried, but getting him to actually do so was a challenge throughout the year.

5.2.2 High Motivation

Students with overly high motivation levels could hardly be considered a problem, but when promoting equity throughout the class, it is something that needs to be taken into
consideration. There was one student in particular that was very enthusiastic about the class who will also be talked about in Chapter 8. Every time I asked a question to the class or asked for a volunteer to perform a problem on the board, he was always the first to raise his hand to try to answer. Even if he didn’t entirely know how to do every step, he would volunteer to try to do whatever he could and let me guide him through the rest; he stressed to me that he would learn it better if he was doing it often and in front of everyone. This was great for me to see in a student, but it was also important that I gave other students the same opportunities as him, without discouraging him by not calling on him. To accomplish this, I would call on him sometimes, but other times I would remind him that other students needed to get involved too. At these times, I sometimes would call on other students with their hands raised, especially those who didn’t frequently participate. Other times, I would cold call on students who didn’t raise their hands, but knew the answer or would benefit from doing the problem in front of the class.

As the class went on, I made a discovery that would allow him to do his work on the board and get other students involved, too: there were multiple whiteboards in the room. When I wanted a volunteer to do a problem on the board and multiple students raised their hands, I would have 2-4 students go to different spots on the two boards in the room to write out their solution. Once they were done, I would go through each of their individual processes, pointing out what they did well and what should be changed. This allowed me to get almost every student involved throughout a class period, as well as evaluate how much of an understanding each student had on the topic we were covering. Ultimately, extra whiteboard space allowed for high equality in class participation in a class period.
Chapter 6: Meets Professional Responsibilities

As a teacher, I was a professional in charge of the education of high school-aged students. This job comes with a lot of responsibilities that it is imperative to meet. It was very important to provide the students with a lesson delivery that enabled them to learn, but these responsibilities stretched far beyond that. Appearance, enthusiasm, and legal obligations are among the responsibilities that I was required to meet during my time as a teacher.

6.1 Appearance

As with most professions, teachers are required to meet a certain dress code. Dress codes are important to creating a sense of authority and professionalism. Dressing up separated me from the students and portrayed a demand for respect. While suit and tie were not necessary, dress pants, nice shoes, and a collared shirt were the bare minimum to meet code and be respected as a teacher. I made sure that I was dressed to meet this code every time I entered the school, as well as being well-groomed. Even if I was well-dressed, if I looked like I had just rolled out of bed, it would portray an image of laziness, thus making it difficult for the students to respect my authority as a teacher. If I looked like I didn’t care about my appearance, it would be impossible for me to convince the students to care about the work that they were doing.

6.2 Enthusiasm

One of the main aspects of delivering an effective lesson is doing it with enthusiasm. This is another very important responsibility that teachers are required to meet. It is not enough to simply provide the information to the students; they will never actually learn it if it is simply presented to them. The teacher, accordingly, must prove to the students that learning the material can actually be enjoyable. Students could not possibly become passionate about learning a subject if they have the impression that the person teaching it to them doesn’t even find it
interesting. They will also have issues in focusing on the lesson if it is presented to them in a plain, boring, and monotone style.

To display enthusiasm in the classroom, I always tried to deliver my lessons with a high energy level. I would speak clearly and audibly and make it very evident that I really cared about the lesson I was delivering. I constantly stressed how interesting the subject matter actually was, often by presenting real-world applications of the topic we were covering. Personally, I found that extreme sports often grasped the students’ attention and made them realize how diverse the applications of physics could be. Therefore, I often showed the class videos of things like skydiving or parkour and had them analyze the physics at play. This displayed my personal interest in applying physics to the real world and hopefully sparked a similar interest in them.

As a teacher, I always tried to give the students the impression that there was no other place in the world that I would rather be than in physics class. Even if I was having a bad day, as all people occasionally do, I had to put it aside and present myself as a professional who was more than happy to be there teaching physics. That way, students would never have an excuse to perform their classwork sloppily if they were having personal problems in their life.

6.3 Legal Obligations

Once a person becomes a teacher, they are immediately held to a higher legal standard than an ordinary citizen. Being in charge of a group of young people carries a lot of responsibilities and there needs to be a way to bind the teacher to them. One example of this that I was fortunate enough to not encounter would be reporting any incidents of domestic violence or home problems to the appropriate people, be it a guidance counselor or the authorities. While I never had to deal with a problem of this magnitude, I did have to manage the daily occurrences that happened in the classroom, mostly revolving around maintaining peace between students. There was one instance, for example, when a student was misbehaving in class and another
student got in his face and told him to stop. I immediately stopped the confrontation between the two and told them both to sit down and leave each other alone for the rest of class. Fortunately, a fight did not break out, but if I didn’t intervene, it could have escalated to the point of physical violence.

Another legal obligation that I had to comply with as a teacher is to be careful as to what I say. The First Amendment grants citizens of the United States the freedom of speech, but once a person becomes a teacher, that right becomes limited. For example, teachers have to be careful that what they say doesn’t offend any student in the class. To make sure that I followed this obligation, I made sure that I never made any references to any race or religion whatsoever. Even the most innocent comment could be construed to be offensive in these areas, so it was best to avoid them completely.

6.4 Parents

Teachers are required to constantly have open lines of communication between themselves and the parents of the students in the class. That way, if a teacher has an issue with anything that the teacher is doing, they have the ability to contact them to discuss the problem at hand. To allow for this, I gave the students my email address that I could be contacted at any time so that a parent could get in touch with me, if need be. I also was present for the Meet the Teachers night that was hosted by the school. While attendance by the parents was fairly low, it was good to get to know the parents that showed up so I was able to inform them about the way the class would be structured and run. This also gave the parents the opportunity to get to know what I was like and how I planned to educate their children. I also presented my email address at this time.
Chapter 7: My WPI Education

Every profession in the world requires some form of training or another to become proficient at it, and teaching is no exception. It would be impossible to get in front of a class of students and teach them a subject if I was not already proficient at it myself. Therefore, it was necessary that I completely master every physics topic that I would be teaching to my students. My education at WPI ensured that I had done this and was fully prepared to portray this knowledge to students who had little to no prior experience.

7.1 Subject Matter

When I was a high school senior, I took the exact same AP Physics class that I was teaching. This was a very helpful first step in my education of the subject matter because I was able to recall the material that I was required to know for the test, as well as the tricks and tactics that I found helpful when I was a student. Since I had taken the class so recently, everything was still fresh in my memory. This actually became very helpful for me to relate to the students when they were struggling with a topic. For example, there was a day that the majority of the students in the class were struggling with a topic and I got the impression that they thought I couldn’t relate to why they were struggling. I used an analogy that Alcoholics Anonymous is run by people who are alcoholics, because only someone who knows what it is like to struggle through something can help another person who is struggling through that same thing. Otherwise, they would only be preaching things that they had heard. I told them how I knew exactly how difficult it could be, since I had struggled when taking the class only 3 years prior. When they realized this and saw how proficient I had become at the subject, it gave them hope that they, too, could master the subject they were learning.

When I first enrolled at WPI, I took physics again, so that I could get a more in depth knowledge of the subject. As was expected, the class was more challenging and covered more
topics than the AP class, but much of the content did carry over. By extending my knowledge of physics beyond the material being covered in the class I was teaching, I was able to guarantee that I was absolutely proficient at everything I would be teaching the students. This is so critical because it would reflect terribly on the teacher if they delivered an incorrect lesson or were unable to answer a question from a student. Having personally been a student in a class where the teacher has been incorrect about the material he/she was teaching, I can testify that the class loses some confidence in the teacher’s abilities, even if it was a simple mistake. Therefore, it was important to me that I knew the material I was teaching, and more, as well as I could.

7.2 Perspective

“When will we ever actually use this?” This question has most likely been asked by every student at one point or another. It is very important that the teacher is able to provide a concrete answer to the class when they encounter this question. Otherwise, it would become almost impossible to motivate the students to learn the material if they knew it would never serve them any good.

In an AP Physics class, the vast majority of students are there because they plan to enter a science-related field for a career someday. This premise alone made it much easier to explain the importance of the subject material to the students, especially because I have the advantage of being an elder who is currently in the process of pursuing a Mechanical Engineering degree. This created a unique scenario where I was personally involved in learning the practical applications of the theoretical knowledge that I was teaching. In my studies, I have taken many advanced physics courses at WPI, including stress, dynamics, thermodynamics, electrical engineering, and many more. One thing that I found, and I made sure to emphasize this to my students, is that all of those advanced classes, in one way or another, related back to the AP Physics class I took when I was a senior. These high-level classes all took the basic topics that I learned in physics,
and analyzed them further and further until an individual topic became an entire class. Without the preliminary knowledge of the physics basics, it would be impossible to progress to these more specialized classes. I stressed this to my students frequently so that they knew that if they wanted to pursue a career in science, they had to master this class first.

Mechanical Engineering requires a lot of hands on applications of the theoretical concepts that are learned, and this is where I could really make a connection to the real-world for the students. My schooling requires me to take many project based classes where I am actually creating a product that had never been made before. The students found this very interesting, because almost everyone has had an idea at one point or another that they would like to see invented. When I would tell the students about these projects, I made it very clear to them that a person cannot simply invent something, but rather have to perform countless calculations and have knowledge of how things actually work so that they could be implemented into a product. Accordingly, even the most advanced calculations and concepts could be traced back to the material that the students were learning. For example, when creating a new product, the material of construction has to be decided upon. To choose a material, you need to base it around the stress it will be encountering and to calculate the stress it will be encountering, you need to have the ability to do force calculations. Just like that I was able to trace the material selection for a new invention back to the basic concept of the equation force equals mass times acceleration. This opened the students’ eyes to how important the course content was if they had any intention of ever pursuing a career similar to mine.
Chapter 8: My Class

In the AP Physics class that I taught, there was a wide variety of students, each with different personalities, motivation levels, English-speaking capabilities, and much more. It was very important to get to know each student personally so that lessons could be delivered to them more effectively. This chapter will address several of the students and their behaviors in the classroom.

Aseel

Aseel was one of the three students that I had that originally came from Iraq. Of the three, his English-comprehension abilities were probably the second best. He spoke fluently and could understand most of the questions that were being asked, but some words confused him, on the premise of language and cultural differences. For example, he was the student that had never heard of baseball before, making me realize that I needed to ask more generic questions. Overall, his English-comprehension abilities did not have major impact on his grade.

Of all the students in my class, Aseel had the largest disparity between motivation level and classroom success. He was easily one of the most motivated and dedicated students in the class and he never had any behavioral issues. He took notes thoroughly, asked questions constantly, did all of his work on time, and participated frequently. Despite this, he never seemed to grasp the concepts that were being taught to the class. This was very frustrating for me as a teacher because it seemed like he was doing all the right things, but for some reason unknown to me, his grades did not reflect his work ethic.

I personally believe that he had some form of disability that inhibited him from retaining information. When the class was working on practice problems, he would ask me for assistance whenever he was struggling and I would help guide him through the problem and he always seemed to make the connections as we went along and sounded confident when we finished.
Then, however, I would assign a very similar problem for homework for that night and he would revert right back to where he started, with difficulties in performing the problem. I tried to combat this by assigning a large amount of practice problems that would reflect the types of questions that would be asked on the test. He would get better after performing more and more, but he still always seemed to make simple mistakes or forget a step in the process. This resulted in his test grades usually being fairly poor.

On a personal level, Aseel was a very friendly student who would always greet me cheerfully when he saw me and was always in a good mood. I found him very easy to talk to, even about things outside of class, such as looking for colleges and what he did in his free time. I think he found me easy to relate to, which resulted in him always being respectful and never giving me a hard time.

**Myles and William (Billy)**

If Aseel is a good example of a student who had high motivation level and low natural talent, Billy and Myles were great examples of just the opposite. Myles was a senior who had already completed an Honors Physics class the previous year and Billy was a junior student who had never taken physics before, but both had demonstrated the ability to easily grasp the concepts being taught to them. Their work ethic, however, left a lot to be desired. This became frustrating because they showed that they had such potential if they simply applied themselves to their work.

Having previous experience with physics definitely benefited Myles in the sense that it gave him a basic understanding of the material the class was learning, thus giving him a head start over other students. This prior knowledge, however, gave him a false sense of confidence about the class. I think he assumed that AP Physics would be easy since he had already taken a physics class, but didn’t realize the great depths that the Advanced Placement level actually gets
into. While most of the concepts are the same between the two, AP Physics analyzes each topic to such an extent that the prior knowledge doesn’t actually become much of a factor at all. His confidence in his knowledge of the material caused him to slack off at the beginning and not do his work. With physics being a class that constantly builds off of previous material, he quickly fell behind and spent the majority of the class struggling to catch up. As shown in the gradebook in Appendix F, he gave very minimal effort on the first several homework assignments and failed to even hand in the summer work. This was frustrating for me as I simply could not convince him that his previous experience wasn’t enough to get him through the year.

Billy’s lack of motivation, on the other hand, was much harder to identify the root of. I never asked him or the school if he did, but I personally believe that he had ADD, or something similar. Every day when class would start he would greet me cheerfully and take his seat, as most students did. But after that, he would never take out a notebook, calculator, or even writing utensil without me reminding him to do so. As the lesson went on, he would simply stare into space until I told him to pay attention, at which point he would do so for a little, then go back into his own world. He would do the exact same thing when I assigned classroom practice problems to the class. Every time, without fail, he would sit there as if he was waiting for me to tell him personally to get to work. Once I finally did tell him to answer the problem, he would do the work, which confused me, because it meant he was not slacking off as an act of defiance.

At first, I thought that Billy did not have a very good chance of being successful in the class, but as I observed his work as the first few weeks progressed, I noticed that everything he did was very well done and thorough. It was at this point that I realized that he was an incredibly bright student, but simply found schoolwork very boring. This was an easy fix, as all I had to do to keep his attention was to find a way to make it interesting to him. Through talking to him, I
found out that he had actually done a lot of daredevil-like activities and extreme sports such as skydiving and deep-sea diving, which was ideal because of all the physics present during these activities. All I had to do when giving a lesson was to somehow relate the content to an extreme sport and suddenly the lesson would grab his attention. One example of this was when we were learning about the Law of Universal Gravitation, I asked the class to calculate the force of gravity acting on Felix Baumgartner when he set the world record for the highest skydive of 24 miles from the surface of the Earth. Questions like these immediately grabbed his attention and resulted in his grades improving drastically as the year went on.

Branden

Branden was a senior in the class and one of only three students who had already taken a physics class in the past, having completed Honors Physics with Mr. Merrill the year before. Although AP Physics contains much more than Honors Physics, the previous experience greatly benefited him as he quickly emerged as one of the highest achievers in the class. He was a very bright individual who always grasped the concepts quickly and scored highly on tests. This caused him, unfortunately, to often slack off and give minimal effort once he realized he could do so and still earn high grades.

I tried very often to get Branden to do his work, and as the year progressed he gradually got better at it. When the year started he was stubborn and would never do classwork or homework, but once I started getting on his case about it, he would generally listen. The slacking generally started once he fully understood the concept being taught and he felt that he didn’t need any more practice. To stop this, I would make a compromise with him that once he finished the practice problem that the class was working on, he could do whatever he wanted until the rest of the class was finished, provided he wasn’t using his cell phone or distracting other students. He responded well to this, doing his work quickly so that he could relax or draw or do what he
wanted. Occasionally, he would revert back to his old self, attributing it to “senioritis,” but eventually would give in and do his work.

Branden and I quickly got on good terms with each other and we ended up forming a strong relationship. As a sport, he fights Mixed Martial Arts and he would frequently talk to me about his fights, since he knew I wrestle and the two sports share a very similar nature. From having this in common and from talking to one-another often during free time, he began to view me as a peer as well as a teacher. This produced both positive and negative results. Since he felt so comfortable with me, he would often try to defy what I said and play jokes on me. One example of this happened when I was teaching the class about free-body diagrams. I told them to keep the drawings as basic as possible, treating every object as either a box or a ball. Brendan was a very artistic person and he found it funny to go against what I said and draw extremely elaborate diagrams with fine details. To preserve my authority as a teacher, I would stop him from doing this whenever he did, but to encourage his participation, every once in a while I would have him come up to the board and draw one of his elaborate pictures. Overall, he never caused any serious problems in the class.

On the opposite end of the spectrum, his peer-like perception of me did often have some good effects. I generally tried to keep a light-hearted atmosphere in the room so that the students enjoyed to be there, but when things started to get out of hand, I would get serious and make the students really buckle down and focus on their work. Since Branden respected me as a peer rather than just an elder teacher, he responded very well when I got serious with him. He understood that in order to earn the right to have fun in class, he also needed to listen when I wanted everyone to be serious and focus. As an extreme case, there once was an instance when another student was getting out of hand and not listening to me despite my best efforts to get the
class to be quiet. Branden stood up, walked over to the student, got in his face, and sternly told him to sit down and not make a sound for the rest of class. This peer pressure caused the other student to do just that. I made sure it didn’t go any further by intervening immediately telling everyone to sit down again, but it was interesting to see a student pressure another student into behaving, rather than the other way around. It made me proud to know I had such a level of respect from a student.

Ali

Ali was another student who came into the class with previous experience in physics, but this prior knowledge did not benefit her nearly as much as it benefitted Brendan. She started off the year strongly, but everyone else quickly caught up, to the point where it was not evident that she had any more experience than anyone else. As a whole she was about average in terms of performance in the class.

Ali had two main issues that resulted in her having difficulties in the class. The first was how talkative she was. It was very hard to get her to focus on what was being taught or what the class was working on because she was always talking to the people next to her. Even when I was delivering a lesson and everyone else around her was paying attention, she would still be trying to hold a conversation with her neighbors. As a result, I constantly had to be reminding her to focus. Occasionally, I would call her out and ask if she had any questions and she would get slightly embarrassed and remain quiet for a little while.

The second issue that inhibited her performance in the class was that of attendance. While I have no attendance records to reference, she had the most absences of the year by far, often missing school for three or four days at a time. Since a lot of physics builds off of previous material, she quickly fell behind in every unit. I tried my best to help her get caught up by doing things like emailing her the PowerPoint slides and even having other students send her the
homework for the night. This worked to a degree, but it is almost impossible to get someone completely caught up on missed material when they miss multiple classes.

Arlind

Of all the students in my class, Arlind was the most motivated and enthusiastic about the class. He showed up every day very intent to learn and excited to cover new material. He never demonstrated that he was overly gifted in physics, but earned good results from constant hard work and dedication. This enthusiasm made him very easy to teach and work with.

As was mentioned in Chapter 5, Arlind was the student that would volunteer to answer every question and to show his work on the board. He continually told me that doing it in front of people made him learn it better. It was because of him that I started using multiple sections of whiteboard to have students show their process for answering practice problems. Because of his great enthusiasm, I never had to worry about him slacking off for he was always intently working on whatever was being taught. He was so anxious to learn that on nights that I didn’t assign any homework to the class, he would ask me for homework anyway so that he could have more practice. I always complied, for I was more than happy to help a student who wanted to do extra work to learn the material better. Arlind also met with me during periods that we both had free to help him with homework problems and with Mr. Merrill on the night before the test to review the material.

Arlind’s passion for the class, coupled with his colorful personality resulted in an interesting event that eventually turned into a class project. One day at the end of class, I saw him writing furiously on a piece of paper, so I asked what he was writing. He told me that he had written a rap about our AP Physics class. After confirming that it was classroom appropriate, I had him perform it to the class. It was extremely well thought out and contained several
equations and terms that we had been using our lessons. He ended up writing several more of these as the weeks progressed to the point where I gave the class the assignment of creating a music video for one of his raps in return for a few extra credit points on the next test. The students were very excited to do this and the results were very beneficial. While this project offered no real intellectual challenge other than incorporating the equations into the lyrics, it got the students involved in something class-related and made them realize that they could have some fun in class. This ultimately resulted in a better learning environment for all the students. Visuals from the video can be seen in Appendix H.

Arlind was also a competitor for the Worcester Public Schools wrestling team, which allowed us to form a connection almost instantly. This enabled him to relate to me easily which is why he was so comfortable asking me to meet with him or asking for additional homework assignments. As a whole, Arlind’s passion for learning, his personality, and his comfort with me and his peers made him a very unique and very easy-to-teach student.

Kiara

In contrast to Arlind, Kiara was a much more reserved and quiet student. She had no prior experience in physics and generally had some difficulties in grasping the material being taught, which resulted in her receiving grades on the lower end, but was nonetheless a very hard worker. Her quieter personality also made her a student that I never had to worry about misbehaving or creating a distraction in class.

When new material was being taught, Kiara was always listening intently and taking good notes, but for some reason, it always seemed to take longer for the problem-solving process to sink in. When I assigned practice problems for the class to work on, she would usually have trouble completing it on her own and I would help guide her through the process. When I did this, it seemed like she started to make connections because she would start to figure out the
steps on her own as we went along and would proceed to do better on her own on the ensuing
problems. When the test came around, however, she seemed to forget all the progress she had
made throughout the unit, resulting in a low test score. This could potentially be a result of some
form of test anxiety that caused her performance to decrease. The use of test corrections,
however, enabled her to usually get her grades into a higher letter grade range.

Eathan

Eathan was a junior in my AP Physics class that seemed to have the most natural ability
in comprehending the material being taught. He had no prior experience in physics, but was
always amongst the first few students to have a thorough understanding of the lesson. This was
overall a good thing, but occasionally led to some problems. The benefits of this were obvious,
as he was able to complete every problem with very little assistance. He also always received
one of the top grades on every test.

Unfortunately, there were some negative side effects of his natural ability in physics. He
was very aware of how talented he was, causing him to feel confident enough to perform the
problem without writing out the necessary work. This caused him to often make simple mistakes
in the process. He also liked to prove that he was the first one to finish the problems and would
announce it to the class as soon as he was done. I had to tell him not to do this because it puts
pressure on the other students to rush through their work. Finally, his knowledge that he
understood all the material with ease caused him to lose focus whenever a lesson was being
taught. I had to constantly remind him to stay on task and focus even though it presented little
challenge to him.

Nikola

Nikola was a senior student in the class. I am unsure if he was an ELL student, as he was
of Greek descent and spoke the language fluently, but also had no difficulties speaking English,
other than his heavy Greek accent. At first, Nikola was a very reserved student who mostly kept
to himself or with one or two other students, but as the year progressed, he began to come out of
his shell and interact more with me and his peers. His Greek nationality actually ended up
providing the class with a humorous incident that turned into a year-long running joke. One day
we were doing a lesson on circular motion and in the calculations we used $\pi$ (pi) and I
pronounced it as “pie,” the way I had always heard it referred to. Upon saying this, Nikola began
to laugh. I asked him what was so funny and he told me that in the United States we pronounce it
wrong and that it is actually pronounced “pee.” This surprised me, as I had never heard this
before. It ended up turning into a joke that whenever we encountered a Greek symbol in an
equation, such as $\mu$ (mu), $\theta$ (theta), and $\tau$ (tau), I would check in with him to see if I was actually
saying it correctly. This helped to loosen him up and let him have some fun in class.

Nikola was one of the best listeners in the class, taking every piece of problem-solving
advice I gave him to heart. This caused him to have great classroom habits, ultimately resulting
in him earning very high grades. When the class was working on a problem, he was always the
most thorough student in the class, writing out literally every single step. I always preached that
this was the best way to avoid making simple mistakes, but most students ignored this advice.
Nikola took my advice, though, and as could be expected, very rarely made a mistake. I made an
example of his work quite often, by having him write out his process on the board, even though
he was sometimes reluctant to volunteer.

One additional anecdote that was a good memory of Nikola’s experience in the class
comes from a time that he showed up to class with a ukulele. I asked what it was for, and he told
me that he and Ali were part of a musical performance that was to take place later that day. I
asked if they wanted to give us a sample of their performance and they were both eager to do so,
with Nikola playing the ukulele and Ali singing a song. The performance was very impressive and the whole class applauded them. Both students seemed to enjoy getting to display their musical talent and had a good, productive morale for the rest of the day. By showing interest in their personal hobbies, they were more willing to participate in my class.

Hammodi

Hammodi was one of the three students from Iraq, and easily the one with the best English-comprehension abilities. He never struggled in understanding a word or scenario, and hardly even spoke with an accent. He also was one of the most gifted students in terms of comprehension ability. He started off earning very high grades, but this changed drastically after the first quarter.

On the first two tests, he performed very well, scoring near the top of the class. His third test and several homework assignments throughout the quarter, however were not so great, eventually lowering his grade for the quarter into the “B” range. For an AP course, a B is a good grade, but Hammodi was devastated to receive a grade lower than an A. This resulted in him having a complete meltdown for the remainder of my time there, to the point where it became almost impossible to get him to lift his head off the table and stop sleeping during lectures and even exams. He would receive his exam, select random answers for the multiple choice, color in the holes in some letters, and hand it in. I pulled him aside one day and asked why he refused to do any work and his response surprised me greatly. He said, “Why should I work hard if I’m going to earn a B when I can do nothing and just take the F.” This shocked me because he clearly cared about his grades immensely, since the entire breakdown was a result of a grade that he considered insufficient.

I tried everything that I could to get him to become engaged in the class again, but it was mostly to no avail. There was one interesting day, however, when I assigned work for the rest of
the class to do and sat with Hammodi and forced him to work. I took my computer and went through every single slide with him one-on-one, not allowing him to do so much as let his eyes wander. When we finished the slides, I gave him a practice problem on the new material and he solved it with incredible ease. This frustrated me greatly because he still had the comprehension ability to excel greatly in the class, but he simply refused to apply himself. This turned out to not be an effective solution because it forced me to take away time from the rest of the class and he simply reverted to sleeping or acting out of line the following day. As upsetting as this was for me, it was a good experience to deal with a student that didn’t respond to literally any form of reward or punishment.

Menhel

Menhel was the third student from Iraq and was the one with the least English-comprehension abilities. He encountered a multitude of words that he did not understand on a daily basis and was the main reason that I changed my questions to be as generic as possible. Whenever a question was asked about a specific situation, he would have difficulties answering it. Even if he had the ability to perform the physics, he would never get the chance to apply his skills because he couldn’t perform the first step of identifying what was happening. I identified this problem quickly and converted over to the system of asking generic questions involving a box or a ball rather than a specific object. This clearly worked, as he either met or exceeded his previous score on every consecutive test (see Appendix F). Having a student like this was a great experience for me because I got the opportunity to work with a very high-needs ELL individual.

Abdul

The final student in the class was a junior named Abdul. Abdul was very quiet and reserved, but overall an easy student to teach. He came in every day with a very good work ethic, taking thorough notes and doing whatever he and the class were told to do. I never had to worry
about behavioral issues with him because of his shy personality. He was a very bright student
and usually understood the concepts being taught after some practice, but I believe that if he was
more expressive, he could have done even better. He never asked me or his peers any questions
if he was confused while completing a problem, so he often was never able to identify what he
was doing wrong for a particular type of problem. When I roamed around the class observing the
students’ work and asking if they needed help, he would never say anything, even if he was
confused. I had to watch him carefully to see if it looked like he was stuck on a certain step for a
period of time, and then I could help him through it. This was beneficial when I noticed him
struggling, but it was impossible to keep a constant eye on him and work with all the other
students at the same time, especially considering the wide range of special attention that certain
students required.

The Class as a Whole

Being not far removed from high school, I have a distinct memory of the atmosphere of
most of the classes I was in. This being said, I cannot recall being involved in a class quite as
unique as this one. The small number of students coupled with the very wide range of
personalities of the students created an atmosphere that was guaranteed to provide new
challenges and entertainment every single day. All the students always seemed to have fun in one
way or another each day, and seemed to mesh well with one another as a whole, despite any
minor instances that occurred from time to time. There were a lot of inside jokes, both amongst
the students themselves and between me and the students, which always ensured that laughs
would be had in the midst of the difficult course material. The students even managed to come
together as a “rap group” referring to themselves as The Scrubs and producing a music video for
a song about physics. Most importantly, the students forged a strong relationship with me, often
coming to me for advice on more than just physics, but rather personal problems in their lives.
The atmosphere of the class is probably best summed up by a quote I overheard Billy saying to Eathan as they walked into class one day: “I don’t care how tough Physics is, coming here is always the best part of my school day.”

**Conclusion**

Having the opportunity to perform my student teaching at Doherty Memorial High School was an experience I will never forget. Being given the responsibility of educating students who were only a few years younger than me in a subject that I am passionate about provided me with a whole new perception of the countless teachers I have known throughout my life. In the process, I learned a lot of strategies that I will be able to utilize if I am fortunate enough to someday be a teacher for a living, and I learned about myself in the process.

During my time as a student teacher, I strove to meet all of the Five Professional Standards for Teachers. It is of my upmost belief that I was successful in this endeavor. I planned the curriculum and my instruction, delivered each instruction effectively, maintained classroom climate and operation, promoted equity, and met my professional responsibilities at all times to the best of my ability. All else aside, I was able to provide my students with new knowledge about the subject of physics and hopefully make an impact on their lives, for they certainly made an impact on mine.
## Appendix A: AP Test Content Outline

### Content Outline for Physics B and Physics C

A more detailed topic outline is contained in the “Learning Objectives for AP Physics,” which follow this outline.

<table>
<thead>
<tr>
<th>Content Area</th>
<th>Percentage Goals for Exams</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Physics B</td>
</tr>
<tr>
<td>I. Newtonian Mechanics</td>
<td>35%</td>
</tr>
<tr>
<td>A. Kinematics (including vectors, vector algebra, components of vectors, coordinate systems, displacement, velocity, and acceleration)</td>
<td>7%</td>
</tr>
<tr>
<td>1. Motion in one dimension</td>
<td>✓</td>
</tr>
<tr>
<td>2. Motion in two dimensions, including projectile motion</td>
<td>✓</td>
</tr>
<tr>
<td>B. Newton’s laws of motion</td>
<td>9%</td>
</tr>
<tr>
<td>1. Static equilibrium (first law)</td>
<td>✓</td>
</tr>
<tr>
<td>2. Dynamics of a single particle (second law)</td>
<td>✓</td>
</tr>
<tr>
<td>3. Systems of two or more objects (third law)</td>
<td>✓</td>
</tr>
<tr>
<td>C. Work, energy, power</td>
<td>5%</td>
</tr>
<tr>
<td>1. Work and work–energy theorem</td>
<td>✓</td>
</tr>
<tr>
<td>2. Forces and potential energy</td>
<td>✓</td>
</tr>
<tr>
<td>3. Conservation of energy</td>
<td>✓</td>
</tr>
<tr>
<td>4. Power</td>
<td>✓</td>
</tr>
<tr>
<td>D. Systems of particles, linear momentum</td>
<td>4%</td>
</tr>
<tr>
<td>1. Center of mass</td>
<td></td>
</tr>
<tr>
<td>2. Impulse and momentum</td>
<td>✓</td>
</tr>
<tr>
<td>3. Conservation of linear momentum, collisions</td>
<td>✓</td>
</tr>
<tr>
<td>E. Circular motion and rotation</td>
<td>4%</td>
</tr>
<tr>
<td>1. Uniform circular motion</td>
<td>✓</td>
</tr>
<tr>
<td>2. Torque and rotational statics</td>
<td>✓</td>
</tr>
<tr>
<td>3. Rotational kinematics and dynamics</td>
<td>✓</td>
</tr>
<tr>
<td>4. Angular momentum and its conservation</td>
<td></td>
</tr>
<tr>
<td>F. Oscillations and gravitation</td>
<td>6%</td>
</tr>
<tr>
<td>1. Simple harmonic motion (dynamics and energy relationships)</td>
<td>✓</td>
</tr>
<tr>
<td>2. Mass on a spring</td>
<td>✓</td>
</tr>
<tr>
<td>3. Pendulum and other oscillations</td>
<td>✓</td>
</tr>
<tr>
<td>4. Newton’s law of gravity</td>
<td>✓</td>
</tr>
<tr>
<td>5. Orbits of planets and satellites</td>
<td></td>
</tr>
<tr>
<td>a. Circular</td>
<td>✓</td>
</tr>
<tr>
<td>b. General</td>
<td></td>
</tr>
<tr>
<td>Content Area</td>
<td>Percentage Goals for Exams</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td><strong>Physics B</strong></td>
<td></td>
</tr>
<tr>
<td>II. Fluid Mechanics and Thermal Physics</td>
<td>15%</td>
</tr>
<tr>
<td>A. Fluid Mechanics</td>
<td>6%</td>
</tr>
<tr>
<td>1. Hydrostatic pressure</td>
<td>√</td>
</tr>
<tr>
<td>2. Buoyancy</td>
<td>√</td>
</tr>
<tr>
<td>3. Fluid flow continuity</td>
<td>√</td>
</tr>
<tr>
<td>4. Bernoulli's equation</td>
<td>√</td>
</tr>
<tr>
<td>B. Temperature and heat</td>
<td>2%</td>
</tr>
<tr>
<td>1. Mechanical equivalent of heat</td>
<td>√</td>
</tr>
<tr>
<td>2. Heat transfer and thermal expansion</td>
<td>√</td>
</tr>
<tr>
<td>C. Kinetic theory and thermodynamics</td>
<td>7%</td>
</tr>
<tr>
<td>1. Ideal gases</td>
<td></td>
</tr>
<tr>
<td>a. Kinetic model</td>
<td>√</td>
</tr>
<tr>
<td>b. Ideal gas law</td>
<td>√</td>
</tr>
<tr>
<td>2. Laws of thermodynamics</td>
<td></td>
</tr>
<tr>
<td>a. First law (including processes on pV diagrams)</td>
<td>√</td>
</tr>
<tr>
<td>b. Second law (including heat engines)</td>
<td>√</td>
</tr>
<tr>
<td><strong>Physics C</strong>: Electric and Magnetism</td>
<td></td>
</tr>
<tr>
<td>III. Electricity and Magnetism</td>
<td>25%</td>
</tr>
<tr>
<td>A. Electrostatics</td>
<td>100%</td>
</tr>
<tr>
<td>1. Charge and Coulomb's law</td>
<td>30%</td>
</tr>
<tr>
<td>2. Electric field and electric potential</td>
<td>30%</td>
</tr>
<tr>
<td>(including point charges)</td>
<td></td>
</tr>
<tr>
<td>3. Gauss's law</td>
<td></td>
</tr>
<tr>
<td>4. Fields and potentials of other charge</td>
<td></td>
</tr>
<tr>
<td>distributions</td>
<td></td>
</tr>
<tr>
<td>B. Conductors, capacitors, dielectrics</td>
<td>14%</td>
</tr>
<tr>
<td>1. Electrostatics with conductors</td>
<td></td>
</tr>
<tr>
<td>2. Capacitors</td>
<td></td>
</tr>
<tr>
<td>a. Capacitance</td>
<td></td>
</tr>
<tr>
<td>b. Parallel plate</td>
<td></td>
</tr>
<tr>
<td>c. Spherical and cylindrical</td>
<td></td>
</tr>
<tr>
<td>3. Dielectrics</td>
<td></td>
</tr>
<tr>
<td>C. Electric circuits</td>
<td>20%</td>
</tr>
<tr>
<td>1. Current, resistance, power</td>
<td></td>
</tr>
<tr>
<td>2. Steady-state direct current circuits with</td>
<td></td>
</tr>
<tr>
<td>batteries and resistors only</td>
<td></td>
</tr>
<tr>
<td>3. Capacitors in circuits</td>
<td></td>
</tr>
<tr>
<td>a. Steady state</td>
<td></td>
</tr>
<tr>
<td>b. Transients in RC circuits</td>
<td></td>
</tr>
<tr>
<td>Content Area</td>
<td>Percentage Goals for Exams</td>
</tr>
<tr>
<td>--------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td></td>
<td>Physics B</td>
</tr>
<tr>
<td>D. Magnetic Fields</td>
<td>4%</td>
</tr>
<tr>
<td>1. Forces on moving charges in magnetic fields</td>
<td>✓</td>
</tr>
<tr>
<td>2. Forces on current-carrying wires in magnetic fields</td>
<td>✓</td>
</tr>
<tr>
<td>3. Fields of long current-carrying wires</td>
<td>✓</td>
</tr>
<tr>
<td>4. Biot-Savart law and Ampere's law</td>
<td>✓</td>
</tr>
<tr>
<td>E. Electromagnetism</td>
<td>5%</td>
</tr>
<tr>
<td>1. Electromagnetic induction (including Faraday's law and Lenz's law)</td>
<td>✓</td>
</tr>
<tr>
<td>2. Inductance (including LR and LC circuits)</td>
<td>✓</td>
</tr>
<tr>
<td>3. Maxwell's equations</td>
<td>✓</td>
</tr>
<tr>
<td>IV. Waves and Optics</td>
<td>15%</td>
</tr>
<tr>
<td>A. Wave motion (including sound)</td>
<td>5%</td>
</tr>
<tr>
<td>1. Traveling waves</td>
<td>✓</td>
</tr>
<tr>
<td>2. Wave propagation</td>
<td>✓</td>
</tr>
<tr>
<td>3. Standing waves</td>
<td>✓</td>
</tr>
<tr>
<td>4. Superposition</td>
<td>✓</td>
</tr>
<tr>
<td>B. Physical optics</td>
<td>5%</td>
</tr>
<tr>
<td>1. Interference and diffraction</td>
<td>✓</td>
</tr>
<tr>
<td>2. Dispersion of light and the electromagnetic spectrum</td>
<td>✓</td>
</tr>
<tr>
<td>C. Geometric optics</td>
<td>5%</td>
</tr>
<tr>
<td>1. Reflection and refraction</td>
<td>✓</td>
</tr>
<tr>
<td>2. Mirrors</td>
<td>✓</td>
</tr>
<tr>
<td>3. Lenses</td>
<td>✓</td>
</tr>
<tr>
<td>V. Atomic and Nuclear Physics</td>
<td>10%</td>
</tr>
<tr>
<td>A. Atomic physics and quantum effects</td>
<td>7%</td>
</tr>
<tr>
<td>1. Photons, the photoelectric effect, Compton scattering, x-rays</td>
<td>✓</td>
</tr>
<tr>
<td>2. Atomic energy levels</td>
<td>✓</td>
</tr>
<tr>
<td>3. Wave-particle duality</td>
<td>✓</td>
</tr>
<tr>
<td>B. Nuclear physics</td>
<td>3%</td>
</tr>
<tr>
<td>1. Nuclear reactions (including conservation of mass number and charge)</td>
<td>✓</td>
</tr>
<tr>
<td>2. Mass-energy equivalence</td>
<td>✓</td>
</tr>
</tbody>
</table>
Appendix B: Lesson Plans
Lesson Plan 9-17-13
Horizontal Projectile Motion

**Do Now:** A ball rolls off a table with a horizontal velocity of 7 m/s. If the table is 1.5 m tall, how long does it take for the ball to hit the ground? How far away from the base of the table does it land?

**Motivation:** Horizontal projectile motion is the first step in solving more complex projectile motion problems.

**Instructional Objective:** SWBAT use kinematics to solve for missing variables in horizontal projectile motion problems.

**Development of lesson:** Ask how the time the ball is in the air would change if the horizontal velocity was doubled. This will help demonstrate that the x and y directions act separately of one another. Then we will move on to more practice problems to make sure everyone is prepared to move on to more advanced projectile motion problems.

A freerunner is on top of a building. He knows he can drop a maximum height of 6 m. He is on top of a building and wants to figure out if he can jump off onto the ground. He kicks a rock off with a horizontal velocity of 3 m/s and it lands 3 m from the base of the building. Can he make the drop? He has to land 7 m from the base of the building how fast does he have to run?

A beach ball, moving with a speed of +1.27 m/s, rolls off a pier and hits the water 0.75 m from the end of the pier. How high is the pier above the water?

0-5: Do now
5-10: go over do now
10-15: doubled velocity example with explanation
15-35: freerunning problem with solution
35-45 other problems
45-55 start to introduce projectiles with initial y velocity
55-70 do example problem on board
70-end give class problems to try
9-17-13
Projectile Motion

Do Now: A cannonball is shot with an initial velocity at an angle above horizontal. If it lands on the same plane it was launched from, how far away does it hit the ground.

Motivation: Projectile motion with an initial y velocity is more realistic and occurs more often than horizontal projectile motion.

Instructional Objective: SWBAT use kinematic equation to solve projectile motion problems with an initial y-velocity

Development of Lesson: Let students work on Do Now for about 5 minutes then solve it on the board slowly so they understand the general process of solving that style of problem. Talk about differences and similarities between horizontal and regular projectile. Acceleration in the x direction is still always zero and the three kinematic equations still always hold true. The only difference is an added initial y-velocity. Also describe how 45 degrees produces the farthest distance. After they have a good handle, give them practice problems to work on. An archer is trying to hit a target on the ground 120 m away. If he shoots at an angle of 60 degrees above the horizontal, how fast must his exit speed be? A person is trying to throw a baseball to his friend on top of a 6 m high roof. If he is 11.5 m away horizontally, and throws at an angle of 63 degrees above the horizontal, how fast must he throw the ball? His friend now throws it back at an angle of 12 degrees below the horizontal. How fast must he throw it to reach him? 2 rock climbers are climbing a mountain and one of them gets injured on a cliff 13 m above the other climber. If they are 7 m away horizontally and the climber on the bottom can throw at a velocity of 32 m/s, at what angle must he throw the first aid kit to reach him so that he catches it at its peak? Ans. 30.258

Homework: Chapter 3 p. 78 #26, 30, 31, 32, 33
9-18-13

Projectile Motion

Do Now: A person is trying to throw a baseball to his friend on top of a 6 m high roof. If he is 11.5 m away horizontally, and throws at an angle of 63 degrees above the horizontal, how fast must he throw the ball?

Motivation: Practice is necessary to perfect the skill of projectile motion problem solving

Instructional Objective: SWBAT use kinematic equation to solve projectile motion problems with an initial y-velocity

Development of Lesson: The lesson will mostly include practice problems with explanations afterwards. They will be taught signifiers that they are working on a projectile problem and how to identify the different parts such as the initial y and x velocities, angle, and what is being asked for. They will be asked to determine how the x and y maximums of a projectile change if the initial velocity was doubled.

His friend now throws it back at an angle of 12 degrees below the horizontal. How fast must he throw it to reach him?

A football kicker lines up to kick a field goal. He is 40m away and the footballs velocity leaving his foot is 23 m/s at an angle of 40 degrees. If the crossbar is 3.05 m high, will he make the field goal? By how much will he make it or miss it?

A golfer at a driving range is driving from the second story which has a height of 3.5 m. If his drive gives the ball a velocity of 23 m/s, 35 degrees from horizontal how much farther will his drive go than if he hit from ground level?
9-19-13

Review Session

Objective: Prepare for the test on the following day.

Procedure: The class will break up into teams of 3. Each team will roll a dice and the number they roll will correspond to a category. They will get a reasonable amount of time to answer the question based on the difficulty and receive 1 point for a correct answer. If they get it wrong the next team in the clockwise direction gets the chance to answer the question. Bonus point on test for winning team

1: Dimensional Analysis
- Convert 62 miles per hour to cm/s (1mi=1.609 km) Ans: 2771.6*
- 1 Year to nanoseconds (1 s =10^9 nanoseconds) Ans: 3.056E16*
- 124 earth pounds to moon pounds (1 earth lb = .166 moon lbs) Ans: 20.6
- 3 Lightyears to mm (c=3E8 m/s) Ans: 2.84E19
- 18,000,000 lbs to oz Ans 2.88E8

2: Graphs
- Draw velocity for parabolic distance*
- Draw acceleration for parabolic distance*
- Draw acceleration for random velocities*
- Draw position for random velocities

3: Vector Addition
- X and y 23m at 61 degrees Ans x 11.2 y 20.11*
- 29 m 32 degrees above horizontal, 40 m 81 degrees above horizontal Ans x 30.9 y 54.9 63 60 degrees*
- 80 m/s 11 degrees above negative x, 66 m/s 31 degrees above positive x Ans x -22.0 y 49.2 53.9 65.9*
- 3.2 m 15 degrees right of positive y, 1.8 m due left Ans x -.97 y 3.3 3.2 72.6*
- 20 m 22 degrees below positive x, 40 m 55 degrees below negative x Ans x -4.4 y -40.3 40.5 83.7

4: 1D Kinematics
- A ball is thrown upward with an initial velocity of 13 m/s. What is its maximum height? Ans 8.45*
- A train accelerates from rest at a rate of 5.6 m/s^2. How long does it take to reach a velocity of 30 m/s Ans 5.36
- A car accelerates from rest to a velocity of 28 m/s over a distance of 78 m. What is its acceleration? Ans 5.025
- A ball is thrown downward at a velocity of 4 m/s. After 8 s what is its velocity? Ans 84
- A car is driving at a velocity of 32 m/s and applies the breaks for an acceleration of -6m/s^2. How far does it take to come to a stop? Ans 85

5: Projectile Motion
- A rock is thrown horizontally at 7m/s off a 10 m high building. How far from the base of the building does the rock land? Ans 9.9*
- An archer shoots an arrow with a horizontal velocity of 38 m/s at a wall 20 m away. How much vertically does it drop in that distance? Ans 1.39*
• A baseball thrown horizontally off a 7m high building hits the ground 22 m away. How fast was it thrown? Ans 18.6
• A ball is launched with a velocity of 31 m/s at an angle of 41 degrees above the horizontal and lands on the same plane. How far away does it land Ans 95.2
• A cannonball is shot at 84 m/s at an angle of 36 degrees above the horizontal. How long does it take to hit its peak? What height is this? What is its velocity at that point? Ans 4.94, 121.9, 68.0 x
Test Day

Objective: Students will take their first exam then do more practice on projectile motion

Procedure: The test will be given during fourth period. Afterwards they will get into groups and play a Scategories style game in which they will calculate as many things as possible for a given set of information about a projectile motion problem.
A ball is kicked with a velocity of 23 m/s at an angle of 30 degrees above the horizontal at a wall 21 m away.
Lesson Plan 9-24-13
Projectile Motion

Objective: SWBAT solve more advanced projectile motion problems

Procedure: Go over test and ask what they think they need to work on. Then do class work for projectile motion problems. Do a basic one first and have every student contribute steps to complete the problem.
A baseball player hits a home run and the baseball clears a wall 21 m high 130 m away. The ball is hit at an angle of 35 degrees and is hit from 1 m off the ground. Find initial speed, time, and total velocity.
Evel Knievel wants to jump a canyon 12 m wide driving up a 15 degree ramp. What must his initial velocity be?
A freerunner wants to jump from one roof to another 6 m below him and 7 m away. What must be his minimum velocity if he wants to clear that gap if he jumps at an angle of 40 degrees?
He is now running with a velocity of 12 m/s and wants to jump onto a ledge. If he jumps at the same angle, what is the highest ledge he can jump onto? How far away must he be when he jumps onto the ledge?
Lesson Plan 9-24-13

Projectile Motion

Objective: SWBAT solve more advanced projectile motion problems

Procedure: Practice Projectile motion problems for the quiz on Wednesday
A baseball player hits a home run and the baseball clears a wall 21 m high 130 m away. The ball is hit at an angle of 35 degrees and is hit from 1 m off the ground. Find initial speed time, and total velocity.
A freerunner wants to jump from one roof to another 6 m below him and 7 m away. What must be his minimum velocity if he wants to clear that gap if he jumps at an angle of 40 degrees?
He is now running with a velocity of 12 m/s and wants to jump onto a ledge. If he jumps at the same angle, what is the highest ledge he can jump onto? How far away must he be when he jumps onto the ledge?
A ship is 2500 m from an island’s 1800 m tall mountain peak, with a ship 610 m away on the other side. If the $v_o$ is 250 m/s at an angle of 75 degrees, how close does the missile come to the other ship and the peak of the mountain?
A kid with a potato gun is trying to hit his neighbor on the other side of a fence. The gun fires with a velocity of 12 m/s at an angle of 60 degrees. If he fires from 10 m away, will he clear the 3.4 m fence?

Homework: Chapter 3 #47(not b), 51, 57, 58,
11-7-13
Lab

**Objective:** Students will perform a lab to help visualize the concepts of conservation of energy

**Procedure:**
- Set up track with ring stand a certain distance away
- Have students calculate the height they need to drop a marble from to get the marble to go through the ring stand
- When the marbles fall short, explain that some energy gets transferred into rotational kinetic energy
- Give rotational kinetic energy equation to help them calculate the new height that the ball must be dropped from
Objective: Students will use their knowledge of conservation of energy and circular motion to make a cart go around a ramp

Procedure:
- Record all necessary measurements about the cart and track
- Calculate the height it needs to be dropped from to make it around the loop with no friction acting on it.
- When it doesn’t make it, perform trial runs to find the point where it finally makes it around the loop
- Using the difference in heights, calculate the work done on the object by friction
Objective: Students will review for their test on energy

Procedure:
1: Work
- A force of 8 N is applied to a block on a horizontal table at an angle of 30 degrees above the horizontal over a distance of 10 m. How much work was done on the block? 69.3 J
- 75 J of work is done on a block over a distance of 20 m. What average force is exerted on the block? 3.75 N
- A 15 kg block slides 3 m down a 30 degree ramp with a coefficient of friction between the two of 0.22. What work is done on the object by friction 85.7 J
- A force of 4 N is applied to a 2 kg box over a distance of 3 m. What is its velocity at this point? 3.46 m/s
- A kg base runner dives for a base with a velocity of 5 m/s. The coefficient of kinetic friction between the player and the ground is 0.4. What is the farthest distance he can dive from to reach the base? 3.125 m

2: Kinetic Energy
- A 1.6 kg soccer ball has a kinetic energy of 12 J. What is its velocity? 3.87 m/s
- A block has a velocity of 2.5 m/s and a kinetic energy of 22 J. What is its mass? 7.04 kg
- A .01 kg marble and a 50 kg rock are moving with the same kinetic energy. If the rock is moving with a velocity of 6 m/s, how fast is the marble moving? 424 m/s

3: Potential Energy
- A 6 kg cat is stuck in a tree at a height of 4 m. What is its potential energy? 240 J

4: Spring Potential Energy
- A ball is attached to a spring and the spring is extended .4 m. If the ball has a spring potential energy of 20 J, what is the spring constant? 250 N/m

5: Conservation of Energy
- A ball falls from a height of 15 m. What is its velocity right before it hits the ground? 17.32
- A 3 kg block slides into a spring with a spring constant of k=75 N/m with a velocity of 11 m/s. How far does the spring get compressed? 2 m
- A ball starts from rest down a slope and back up a slope with a radius of 5 m. If the ball just loses contact with the slope at the top of the slope, how far below the original point is the top of the slope? 2.5 m
- A ball on the end of a string is hit with an initial velocity of 6 m/s. If it loses 40% of its energy due to air resistance, what height does the ball attain? 1.08 m
- A 3 kg block falls from an unknown height onto a spring with a constant of 100 N/m and compresses it .8 m. What is the change in height from the bottom of the spring to the point it was dropped from? 1.06 m
6: Power

- A 55 kg person runs up 6 flights of stairs in 30 seconds. If each flight is 1.8 m, how much power did this take? 198 W
- How much energy does a 100 W bulb consume in 1 hour? 360000 J
Crash test momentum

**Objective:** SWBAT calculate use momentum to solve problems in real life scenarios

**Procedure:**
- Watch crash test videos with crash test dummies and talk about the momentum significance of seatbelts, air bags and crumple zones
- Calculate the maximum velocities a person could survive a crash at dependent of seatbelts, air bags, and crumple times
- An airbag can bring a person to a stop in 35 milliseconds. What is the maximum speed they can drive their car into a wall at and how much force is exerted on them?
- Without an airbag, the collision will only take 5 milliseconds. What is the new maximum speed and force?
Momentum Quiz

Objective: Students will take a vocab quiz and practice on advanced momentum problems

Procedure:
- Give vocab quiz to students for about 10 minutes
- Give advanced momentum challenge problem and let students solve
- Blocks of mass \( m \) and \( 2m \) are positioned on a semicircular frictionless track at a height of \( R/4 \) above the lowest point. The blocks are released simultaneously and collide elastically at the bottom of the track. How high does each block rise after the collision?
Appendix C: PowerPoint Slides

Slide 1

Gravity

Slide 2

History
- Sir Isaac Newton
- Sat under an apple tree and got hit by an apple, sparking an investigation on the force of gravity

Slide 3

What is gravity?
- How would you define gravity?
- What causes it?
- What objects have a force of gravity between them?
- Gravity is a universal force between any two objects that have mass. The force between them is dependent on the mass of each object and the distance between them.
- Scientists are still unsure as to why gravity actually exists

Slide 4

Calculating gravity
- The acceleration due to gravity here on Earth is 9.81 m/s² dependent on location
- How would we calculate the acceleration due to gravity on a different planet?
- $F = \frac{GMm}{r^2}$
- What is $r$ a value of?

Slide 5

G
- Henry Cavendish (~1798) determined the value of G
- $G =$ Universal Gravitational Constant
- $G = 6.67 \times 10^{-11}$ m³/kg·s²

Slide 6

Prove 9.81
- $M = 5.97 \times 10^{24}$ kg
- $r = 3.96 \times 10^6$ m
- What is the acceleration due to gravity on top of Mount Everest? Mt. Everest is 8.9 km tall
Slide 7

**GRAVITY**

- What would a 63 kg person weigh on the moon? The moon has a mass of $7.35 \times 10^{22}$ kg and a radius of 1737 km.

Slide 10

**SKY DIVE**

- Felix Baumgartner completed the highest ever sky dive last year. He successfully jumped from a height of 21.7 km above the Earth's surface. At this height, what is the force of gravity acting on him and what is his acceleration? Assume his weight is 70 kg.

- $F_g = 680.1 \text{ N}$
- $a = 9.71 \text{ m/s}^2$

Slide 8

**PRACTICE**

- An astronaut weighing 700 N on Earth travels to the planet Mars. What does the astronaut weigh on Mars? (The mass of Mars is 0.107 times that of the Earth's mass. The radius of Mars is 0.530 times that of the Earth's radius.)

- $m = 260.8 \text{ N}$

Slide 11

**CIRCULAR GRAVITATION**

- A satellite of mass 1000 kg is orbiting the earth at a distance of $3 \times 10^6$ m above the surface of the earth. What is the force of gravity acting on it?

- $F_g = 4525.8 \text{ N}$
- $v = 6515.5 \text{ m/s}$

Slide 9

**PRACTICE**

- What was the gravitational force exerted by Sir Isaac Newton on the apple when it fell on him? Sir Isaac Newton had a mass of 63 kg and the apple had a mass of 0.5 kg and fell from a height of 6 m.

- $F_g = 1.84 \times 10^{-11} \text{ N}$

Slide 12

**CIRCULAR GRAVITATION**

- The moon orbits the earth with a speed of 1022 m/s. What is the distance between the centers of the earth and moon?

- $3.8 \times 10^5 \text{ m}$
**Slide 13**

**PRACTICE**
- Jupiter's moon Europa has an average orbital radius of $6.67 \times 10^8$ m and a period of 85.2 hours. Calculate the magnitude of its average orbital speed and the centripetal acceleration of Europa.
- $v=1.444 \text{ m/s}$
- $a_c=280 \text{ m/s}^2$

**Slide 15**

**PRACTICE**
- In the Andromeda Galaxy, scientists have located a binary star system. This is a solar system with two large sun-like stars. The stars are 7.5 times 10^15 m apart. The first sun has a mass of 2.55 times 10^27 kg, and the other sun is observed to be 3 times bigger. A small planet (5.2 times 10^12 kg) is located midway between the two stars.
- Draw an FBD for the planet.
- What is the net force on the planet? What is the direction of this net force?

**Slide 16**

**KEPLER'S LAWS**
- Kepler's 1st Law - The path of each planet about the sun is an ellipse, with the sun at one focus.
- Kepler's 2nd Law - Each planet moves so that an imaginary line drawn from the sun to the planet sweeps out equal areas in equal times.
- Kepler's 3rd Law - The ratio of the squares of the periods of any two planets orbiting about the same central gravitational body is equal to the cubes of their average distances from the sun:

$$\frac{T_1^2}{T_2^2} = \frac{R_1^3}{R_2^3}$$

**Slide 17**

**KEPLER'S 2ND LAW**

**Slide 18**

**KEPLER'S 3RD LAW**
- $A_1^{1.5} = A_2^{1.5}$ for any two bodies orbiting the same body
Planet Sid and Planet Barky both orbit the same central gravitational body (sun). Planet Sid orbits this sun at a speed of 12,253 m/s at a distance of $8.84 \times 10^9$ m. Planet Barky has an orbital period of $5.68 \times 10^7$ sec.

- Calculate the orbital period of Planet Sid.
- Calculate the orbital radius of Planet Barky.

Work

- Work is a value of a force in a certain direction exerted over a distance.
- Only a force in the same direction as the displacement is taken into account for measuring work done on an object.
- $W = F \cdot d \cdot \cos \theta$
- $F$: Force
- $d$: distance
- $\theta$: angle between the force and displacement vectors
- Measured in a unit called Joules.

Practice

A box is pushed across a frictionless floor with a horizontal force of 30 N over a distance of 15 m. What is the net work done on the box?
- $W = 450 \text{ J}$

Practice

A box is pushed across a floor with a force of 15 N at an angle of $20^\circ$ below the horizontal over a distance of 9 m. What is the work done by the applied force on the box? If the box has a mass of 5 kg and a coefficient of kinetic friction of 0.15 between itself and the floor, what is the work done by friction on the box?
- $W = 127 \text{ J}$
- $W = 74.4 \text{ J}$
What is energy?
Energy is the ability to do work.
What are some different types of energy
Energy is also measured in Joules

In this class we deal with three types of energy, all of which fall under the category of "mechanical energy":
- Kinetic Energy
- Gravitational Potential Energy
- Spring Potential Energy

Kinetic Energy (K)
- Kinetic Energy is the energy possessed by a moving object
  \[ K = \frac{1}{2}mv^2 \]
  \( m \): mass
  \( v \): velocity

Gravitational Potential Energy (U)
- Gravitational Potential Energy is the energy that is possessed by an object due to its potential to fall from a certain height
  \[ U = mgh \]
  \( m \): mass
  \( h \): height

Practice
- A 0.5 kg ball is thrown with a velocity of 32 m/s. How much kinetic energy does the ball have?
  \[ K = \frac{1}{2} \times 0.5 \times (32)^2 = 256 \text{ J} \]
- A 2 kg box is held in the air at a height of 20 meters. How much potential energy does it have?
  \[ U = 2 \times 9.8 \times 20 = 392 \text{ J} \]
Conservation of Energy

- Energy is always conserved
- The total amount of energy at one point will be equal to the total amount of energy at any other point throughout the motion
- Knowing the specific energy value of an object at a certain point doesn’t tell us much, but knowing that the energy will remain constant throughout the objects motion allows us to calculate values that are important
- $E_1 = E_2 = E_3 = \ldots$

Conservation Of Energy

- Energies that are not being changed do not need to be included when breaking down the equation.
- $K_1 + U_1 + U_{s1} = K_2 + U_2 + U_{s2}$

Practice

- A ball is dropped from rest from a height of 15 m. What is the ball’s velocity when it hits the ground?
  - $v = 17.3 \text{ m/s}$

- A ball is shot upwards at an angle with a velocity of 16 m/s. When it hits its peak, it has a velocity of 6 m/s. What is the ball’s height?
  - $h = 14 \text{ m}$

- A box slides down a frictionless ramp. If it starts at a height of 3 m, what is the box’s velocity when it hits the bottom?
  - $v = 7.75 \text{ m/s}$

Spring Potential Energy (Us)

- When a spring is extended or compressed, it creates a potential to set an object into motion.
- How can we derive an equation for the potential energy created by displacing a spring from equilibrium?
We have a spring with a spring constant of $k=100$ N/m that is attached to a 5 kg mass. The system is at rest on a horizontal, frictionless surface. The spring is compressed a distance of .3 m from equilibrium.

- What is the spring potential energy at this point?
- At what point after it is released will it have the greatest velocity? What is that velocity?
- How far will it extend the spring?

A 6 kg block slides into a spring with a spring constant $k=150$ N/m at a velocity of 10 m/s. How far will the spring be compressed?

$x=2 \text{ m}$

A 3 kg block is dropped from a certain height. It hits a spring with a stiffness constant of $k=75$ N/m and compresses it a distance of .7 m.

- What is the block’s velocity right before it hits the spring?
- What is the vertical height from where the block was dropped from to where it comes to a stop?

A box slides across a floor and slides to a stop. What happened to the kinetic energy?

Energy is dissipated as a result of friction

$W=ΔK$

A force of 15 N is exerted on a box on a frictionless surface over a distance of 7 m. What is its velocity at this point?
Slide 24

Practice

- A box is sliding across a floor with a coefficient of friction of 0.42 at a velocity of 10 m/s. How far will it slide before coming to a stop?

Slide 25

Practice

- A 7 kg box is resting on a table with a coefficient of kinetic friction between the two of 0.25. It is connected via string and pulley to a 5 kg box hanging off the edge of the table. The 5 kg box falls a distance of 3m.
  - What is the work done on the 5 kg box by gravity?
  - What is the work done on the 7 kg box by friction?
  - What is the final velocity of the system?

Slide 26

Practice

- A 0.8 kg ball hangs on the end of a 3.0 m cord. It is hit by a child and rises vertically 2.1 m from the ground.
  - What is the ball's velocity right after being hit?
  - If air resistance removes 20% of the mechanical energy of the system, what will be the new maximum height of the ball?

Slide 27

Circular Motion

- The circular motion problems can be analyzed from an energy and work standpoint, also.
  - How much work is done by the force that creates a centripetal acceleration?
  - None! Centripetal forces act perpendicular to the displacement.

Slide 28

Circular Motion

- A roller coaster is going around a loop of radius 15 m.
  - What is the minimum velocity it needs to have to make it to the top of the loop?

Slide 29

Practice

- A 1 kg toy car is pulled back .2 m on a spring with spring constant of k=75 N/m. The first part of the path goes through a loop. What is the maximum radius of the loop it can go through successfully?
  - The car then goes off a jump so that when it hits its peak it has a velocity of 2 m/s. What is the maximum height it can reach?
  - It then lands and hits a spring with a spring constant of k=125 N/m. How far does it compress the spring?
**Power**

- What is power?
- Power is the ability to do work in a certain amount of time
- \( P = \frac{W}{t} \)
- Metric unit is called a Watt, English unit is called horsepower

**Power**

- A person pushes a box 10 m across a frictionless surface with a force of 15 N in a time of 3 seconds. How much power is required to do this?
- 50 W

**Practice**

- A box is pushed with a constant force of 25 N. Throughout its motion, it has an average velocity of 6 m/s. How much power is necessary to do this?
- 150 W

**Rotational Kinetic Energy**

- \( K_R = \frac{1}{2}mv^2 \)
Appendix D: Teenage Mutant Ninja Turtle Lab

Setup: Donatello is ready to take on a new activity: bungee jumping! His plan is to take the leap of faith from the top of the staircase. Being the adrenaline junkie he is, though, he wants his jump to bring him as close as possible to the ground. Be careful though, because hitting the ground could be deadly!

Task: You are in charge of giving Donatello the most thrilling bungee jump possible. To do so you must design the bungee that he uses to jump with. The first part of the bungee will be 2 meters of ideal string. The remainder will be a series of connected rubber bands that ultimately attach to Donatello. The amount of rubber bands is up to you!

Procedure: This part is up to you and your group. Perform whatever measurements and calculations you feel are necessary to minimize the final distance between Donatello’s head and the ground below. There are many ways to do so, but remember the vital variables that need to be known such as mass, spring constant, and height.

Rules: The team who gets Donatello closest to the ground without hitting the ground wins! That team will receive the greatest prize possible: the feeling of victory over their fellow competitors.
Appendix E: Exams

Exam #1
Kinematics and Vectors

Name______________________________                                                    Date_____________

This is a 45 minute exam that will cover the entire unit of Kinematics and Vectors. The score is out of 100 points. Partial credit can be earned on open ended questions. Your resources are a calculator and the given equation sheet. Round all answers to the correct amount of significant figures. Knowledge of topics from previous units is assumed. Assume \( g = -10\text{m/s}^2 \).

Multiple Choice (20 questions x 3 points each, approx. 25 minutes)

1. Convert 75 mi/hr to m/s (1 mi = 1.609 km)
   a. 12.9 m/s
   b. 33.5 m/s
   c. 120.7 m/s
   d. 46.6 m/s

2. Convert 210 kg to oz (1 kg = 2.2 lbs, 1 lb = 16 oz)
   a. 1527.3
   b. 28.9
   c. 6.0
   d. 7392

3. Convert 3.5 hrs to nanoseconds (1 second = \( 10^9 \) nanoseconds)
   a. \( 1.26 \times 10^{13} \)
   b. \( 3.60 \times 10^{12} \)
   c. \( 3.50 \times 10^9 \)
   d. \( 1.30 \times 10^{-5} \)
Use the following graphs to answer questions 4-7:

4. Which graph represents a cart with a motor accelerating until it hits a wall?
   a. A  
   b. B  
   c. C  
   d. D

5. Which graph represents a car stopped at a stoplight, then accelerating until its continues with a constant velocity
   a. A  
   b. B  
   c. C  
   d. D

6. Which graph represents a ball being thrown into the air and coming back down?
   a. A  
   b. B  
   c. C  
   d. D

7. Which graph represents a car driving, braking for a crossing deer, then accelerating back up to speed?
   a. A  
   b. B  
   c. C  
   d. D
8. A person walks 42 m at an angle of 31 degrees above the positive x-axis then 18 m at an angle of 73 degrees below the positive x-axis. What is their displacement?
   a. 31.1 m, 17 degrees above positive x-axis
   b. 31.1 m, 17 degrees below positive x-axis
   c. 41.5 m, 6.11 degrees above positive x-axis
   d. 41.5 m, 6.11 degrees below positive x-axis

9. A football player runs 8.3 m at an angle of 13 degrees above the negative x-axis then runs straight forward for 26 m to catch a pass. What was his total displacement?
   a. 25.5 m, 71.4 degrees above the negative x-axis
   b. 12.0 m, 32.6 degrees above negative x-axis
   c. 29.0 m, 73.8 degrees above negative x-axis
   d. 15.3 m, 66.8 degrees above positive x-axis

10. What is the total distance travelled by the football player in Question 9?
    a. 29.3 m
    b. 34.3 m
    c. 36.0 m
    d. 26.0 m

11. A car travelling at a rate of 13 m/s accelerates at a rate of 3.5 m/s² until it reaches a speed of 21 m/s. How long did this take?
    a. 2.29 s
    b. 6.00 s
    c. 3.71 s
    d. 0.80 s

12. A ball is thrown straight upward with an initial velocity of 16 m/s. What is its height when the ball hits its peak?
    a. 12.8 m
    b. 51.2 m
    c. 25.6 m
    d. 0.8 m

13. A brick is dropped from a 23 m high apartment building. How long does it take to hit the ground?
    a. 4.6 s
    b. 2.3 s
    c. 1.5 s
    d. 2.1 s
14. An object is thrown horizontally off a building with initial velocity $v_1$ and it takes time $t$ to hit the ground. If $v_1$ is doubled, by what factor does $t$ change?
   a. 1
   b. 2
   c. 4
   d. Not enough information

15. 2 vectors, each with a magnitude of 10 m and unknown direction, are placed on a graph with the second one beginning where the first one ends. Which of the following could be the magnitude of the resultant vector?
   a. 0
   b. 10
   c. 20
   d. All of the above

16. 2 astronauts on the Mars are trying to determine the acceleration due to gravity, $g$. To do so one drops a ball from height $y$ while the other one measures the time, $t$, it takes to hit the ground. What is the acceleration due to gravity?
   a. $g=\sqrt{2y/t}$
   b. $g=\sqrt{y/t}$
   c. $g=2y/t^2$
   d. $g=y/t$

17. A ball is thrown straight upward and comes down. This motion can be broken up into 3 stages i) going up, ii) at its peak, and iii) coming down. What is its acceleration for each of these stages?
   a. i) $10 \text{ m/s}^2$ ii) $0 \text{ m/s}^2$ iii) $-10 \text{ m/s}^2$
   b. i) $-10 \text{ m/s}^2$ ii) $-10 \text{ m/s}^2$ iii) $-10 \text{ m/s}^2$
   c. i) $-10 \text{ m/s}^2$ ii) $0 \text{ m/s}^2$ iii) $-10 \text{ m/s}^2$
   d. i) $-10 \text{ m/s}^2$ ii) $0 \text{ m/s}^2$ iii) $10 \text{ m/s}^2$

18. A car drives with a velocity of 30 m/s for 15 km. It then rests for 30 minutes. Finally it drives 90 km in a time of 1 hour. What is the car's average velocity?
   a. 30.0 m/s
   b. 17.8 m/s
   c. 25.0 m/s
   d. 60.0 m/s

19. A runner runs the first 2.5 km of a 5k road race with a constant speed of 6 m/s. She then increases her speed and runs the remainder of the race with a velocity of 7.5 m/s. What is her average velocity for the race?
   a. 6.67 m/s
   b. 6.00 m/s
   c. 7.5 m/s
   d. 6.75 m/s
20. A target is hanging in a tree and you are attempting to shoot at it with a bow and arrow. As soon as you release the arrow, the target will start freefalling towards the ground. To hit the target you should:
   a. Aim above the target
   b. Aim below the target
   c. Aim at the target
   d. Aim at the ground

Open Ended (2 questions x 20 points each, approx. time 25 minutes)

1. A rock is thrown horizontally off a roof with an initial velocity of 16 m/s. It lands on the ground 20 m from the base of the building.
   a. Calculate the time it takes for the rock to hit the ground.
   b. How tall is the building?
   c. What is the rock’s vertical velocity when it hits the ground?
   d. How far from the ground is the rock after .75 seconds?
e. Another person on top of the roof throws a rock straight downward 1 second after the first was thrown so they hit the ground at the same time. How fast was it thrown?

2. A cannon shoots a cannonball with an initial velocity of 65 m/s at an angle of 30 degrees above the horizontal. The cannonball lands on the same level it was shot from.
   a. Draw position, velocity, and acceleration vs. time graphs for the cannonball’s motion in the y direction.

b. How high is the peak of the cannonball’s path?

c. How long does it take to reach the peak?
d. How far away from the cannon does it land?

e. If the initial velocity of the cannonball was tripled, by what factor would the x and y maximum values change?
Exam #2
Forces

Name______________________________                                                    Date_____________

This is a 60 minute exam that will cover the entire unit of Forces. The score is out of 100 points. Partial credit can be earned on open ended questions. Your resources are a calculator and the given equation sheet. Round all answers to the correct amount of significant figures. Knowledge of topics from previous units is assumed. Assume g=10m/s².

Multiple Choice (20 questions x 3 points each, approx. 25 minutes)

1. A box is being suspended from two cords as shown. What is the force of tension in Cord 1?

![Diagram of a box suspended by two cords at 45° angles, with a 200 N force applied]

a. 50 N  
b. 71 N  
c. 141 N  
d. 283 N

2. Two masses of mass \(m_1\) and \(m_2\) are hung over a frictionless pulley. If \(m_1 > m_2\), what will be the downward acceleration of \(m_1\)?

a. \(g\)  
b. \(\frac{(m_1-m_2)g}{m_1+m_2}\)  
c. \(\frac{m_1g}{m_2}\)  
d. \(m_1m_2g\)

3. A 60 N force is required to start sliding a 10 kg box across the floor. What is the coefficient of static friction?

a. 0.60  
b. 0.17  
c. 0.80  
d. 0.35

4. A block is released from rest on top of a ramp that makes a 45° angle with the horizontal. After 2 seconds, it travelled a distance of 12 m. What is the coefficient of kinetic friction between the block and the ramp?
5. A 55 kg person is standing on a scale inside an elevator. If the scale reads 450 N, what must be the acceleration of the elevator?
   a. 1.8 m/s\(^2\) downwards
   b. 1.8 m/s\(^2\) upwards
   c. 0.55 m/s\(^2\) downwards
   d. 0.55 m/s\(^2\) upwards

6. A 15 kg block and a 6 kg block are connected by a string and are resting on a frictionless surface. The 15 kg block is pulled with a force of 30 N. What is the tension in the string between the two blocks?
   a. 12.0 N
   b. 9.4 N
   c. 2.3 N
   d. 8.6 N

7. A box is sliding at a velocity of 5 m/s and starts up a 30° frictionless ramp. How far up the ramp does it travel before coming to a stop?
   a. 5.0 m
   b. 2.5 m
   c. 10 m
   d. 1 m

8. A person’s shoes have a coefficient of static friction of 0.68 between the sole and the ground. What is the fastest acceleration they can run with without slipping?
   a. 68 m/s\(^2\)
   b. 6.8 m/s\(^2\)
   c. 0.68 m/s\(^2\)
   d. Depends on mass

9. A girl is pushing a 0.6 kg book against the wall and slowly releases the force she is applying to it. The book starts to fall when the force against it becomes 11 N. What is the coefficient of static friction between the book and the wall?
   a. .60
   b. .05
   c. .54
   d. .11

10. A spring pushes a block horizontally against a scale and is compressed 25 cm. If the scale reads a normal force of 120N, what is the stiffness constant of the spring?
11. A professional baseball player hits a baseball with a baseball bat. Which of the following statements is true?
   a. The bat exerts a greater force on the ball than the ball does on the bat
   b. The ball exerts a greater force on the bat than the bat does on the ball
   c. Both the bat and the ball exert an equal force on each other
   d. Not enough information

12. The following picture depicts a pulley system in equilibrium:

What is the weight reading on the scale?
   a. 60 N
   b. 40 N
   c. 80 N
   d. 0 N

13. A box is resting on a 10° frictionless ramp. What is its acceleration down the ramp?
   a. 0.17 m/s²
   b. 10.00 m/s²
   c. 3.47 m/s²
   d. 1.74 m/s²

14. A box is resting on a plane with friction. One end of the plane is lifted, creating a ramp, until the box begins to slide at an angle of 41°. What is the coefficient of static friction?
   a. 0.66
   b. 0.87
   c. 0.75
d. 0.41

15. A racecar is travelling at a rate of 41 m/s. The driver slams on the brakes so the tires start skidding. If the coefficient of kinetic friction between the tires and the road is 0.89, how far will the car travel before coming to a stop?
   a. 94.4 m
   b. 188.9 m
   c. 4.94 m
   d. 45.2 m

Use the following diagram for problems 16-17

![Diagram of three blocks connected by strings](image)

16. If the coefficient of kinetic friction between the 5 kg block and the table is 0.22, what is the acceleration of the system?
   a. 4.71 m/s²
   b. 3.06 m/s²
   c. 5.44 m/s²
   d. 2.75 m/s²

17. What is the tension in the string that connects the 21 kg block and the 5 kg block?
   a. 15.2 N
   b. 204.5 N
   c. 98.1 N
   d. 152.3 N

18. A 45 kg sled is pulled by a rope that makes an angle of 45 degrees with the horizontal. If the coefficient of friction between the snow and the sled is 0.10 and the rope is pulled with a force of 150 N, what will be the acceleration of the sled?
19. A 50 kg tightrope walker stands in the middle of the tightrope causing the rope to be at an angle of 10° below the horizontal at both ends. What is the tension in the rope?
   a. 145.3 N  
   b. 2031.6 N  
   c. 2879.4 N  
   d. 1439.7 N

20. A 68 kg man stands on a scale that is at rest on a 15° ramp. What is his apparent weight?
   a. 656.8 N  
   b. 176.0 N  
   c. 704.0 N  
   d. 2627.3 N

Extra Credit (2 points):
Who was Mr. Merrill’s college Differential Equations professor?

Open Ended (2 questions x 20 points each, approx. time 25 minutes)
1. A 6 kg block rests on a frictionless 45° ramp connected by string and pulley to a 9 kg block resting on a frictionless 30° ramp.

   a. Draw a Free-body Diagram for the system (do not resolve forces into their components).
b. Calculate the acceleration of the system.

c. Calculate the force of tension in the string.

d. Calculate how far the 6 kg block slides after 3 seconds.

e. If the system starts from rest again and the string is cut, calculate how long it will take the 9 kg block to slide 5 m.

2. A 4 kg block is resting on a 25° ramp with a coefficient of kinetic friction between the two of 0.23. It is connected via string and pulley to an 8 kg block hanging off the edge of the ramp.
a. Draw a **Free-body Diagram** for the system (do not resolve forces into their components).
b. Calculate the acceleration of the system.

c. What will be the velocity of the 4 kg block after 1.5 seconds?

d. If there was a scale under the 4 kg block, what would its apparent weight be?

e. The string is cut when the system is at rest. If the 4 kg block started 1 meter above the ground, and it makes a smooth transition to the ground with the same coefficient of friction, how long will it take for the block to come to a stop?
Exam #3
Circular Motion and Universal Gravity

Name______________________________                                                    Date________

This is a 60 minute exam that will cover the entire unit of Circular Motion and Universal Gravity. The score is out of 100 points. Partial credit can be earned on open ended questions. Your resources are a calculator and the given equation sheet. Round all answers to the correct amount of significant figures. Knowledge of topics from previous units is assumed. Assume g=10m/s^2.

Multiple Choice (10 questions x 5 points each, approx. 25 minutes)

1. If a ball were being swung on a string in counterclockwise motion and the string were cut at the point shown, which path best describes the motion of the ball after the string was cut?
   
   ![Diagram of a ball on a string]

   a. A  
   b. B  
   c. C  
   d. D

2. What force of friction is necessary to keep a 1000 kg car in motion around a turn with a radius of 70 meters if the car is travelling at a rate of 25 m/s?
   
   a. 8929 N  
   b. 1000 N  
   c. 357 N  
   d. 5102 N

3. A 0.5 kg toy plane attached to a string is being swung around in a circle. The string is at an angle of 15° with the horizontal like so:

   ![Diagram of a toy plane on a string]

   If the 1.5 m long string has a tension of 25 N, how fast must the plane be moving?
4. There is an amusement park ride where the people stand against the walls of a cylindrical room and the room spins around at a high velocity. The floor then drops out, but the people remain stuck to the wall. If the radius of the ride is 5.5 m and the coefficient of static friction between the wall and a person is 0.91, how fast must the ride spin to keep the people stuck to the wall?
   a. 10.8 m/s
   b. 4.2 m/s
   c. 7.8 m/s
   d. 32.1 m/s

5. How much would a 63 kg man weigh on Jupiter? Jupiter has a mass of $1.90 \times 10^{27}$ kg and a radius of 69911 km.
   a. 1556 N
   b. 630 N
   c. 2531 N
   d. 1023 N

6. An astronaut lands on a planet whose mass and radius are each twice that of Earth. If the astronaut weighs 800 N on earth, how much will he weigh on this planet?
   a. 800 N
   b. 1600 N
   c. 400 N
   d. 3200 N

7. The Earth exerts a force of gravity of 1900 N on an object at a distance of $2.5 \times 10^6$ m from the surface of the Earth. What is the mass of the object?
   a. 190 kg
   b. 250 kg
   c. 582 kg
   d. 376 kg

8. A ball attached to a string swings in a horizontal circle around a pole. The string makes an angle of 25° with the vertical. What is the angle between the velocity and acceleration vectors?
   a. 25°
   b. 90°
   c. 180°
   d. Not enough information

9. The Universal Gravitational Constant, $G$, is:
a. Equal to \( g \) at the Earth’s surface  
b. Different on the moon than on earth  
c. The same for calculating gravity between objects that are close together as it is for planetary gravity  
d. None of the above

10. Earth is 149,600,000 km from the sun. If Venus is 108,000,000 km from the sun, how long does a year last on Venus?  
   a. 224 days  
   b. 183 days  
   c. 264 days  
   d. 365 days

Extra Credit (1 point): What is the mass of Pluto?

Open Ended (2 questions x 25 points, approx. 35 minutes)

1. A car takes a turn that has a radius of 40 m. The road is banked at an angle of 23°.  
   a. If there is no friction in the road, draw a free body diagram for the car on the turn.  
   b. At what velocity must the car drive to make it around the frictionless turn  
   c. If the car then tries to take turn around a vertical road with friction, draw a free body diagram  
   d. Calculate the normal force acting on the car
e.  If the radius of the vertical turn is 25 m and the car travels at a velocity of 31 m/s, calculate the necessary coefficient of static friction between the tires and road.

2. A 1500 kg satellite is orbiting the Earth at a distance of $3.5 \times 10^6$ m from the surface of the Earth.
   a. Calculate the force of gravity acting on the satellite

   b. Calculate the velocity the satellite is moving at

   c. How long does it take the satellite to orbit the Earth?

   d. If that velocity was doubled, how far from the surface of the Earth must the satellite be?

   e. If the Earth were to suddenly disappear, describe the following motion of the satellite.
Exam #4
Energy

Name______________________________                                                    Date_____________

This is a 60 minute exam that will cover the entire unit of Work, Energy, and Power. The score is out of 100 points. Partial credit can be earned on open ended questions. Your resources are a calculator and the given equation sheet. Round all answers to the correct amount of significant figures. Knowledge of topics from previous units is assumed. Assume g=10m/s^2.

Multiple Choice (15 questions x 3 points each, approx. 25 minutes)

1. Two rocks, one twice as heavy as the other, are dropped from the top of a building. Just before they hit the ground, the heavier rock has:
   a. The same amount of kinetic energy
   b. Twice as much kinetic energy
   c. 4 times as much kinetic energy
   d. Half as much kinetic energy

2. A block of mass, \( m \), is dropped from a height, \( h \). On the way down, an air resistance force, \( F \), acts on it. What is the block's kinetic energy at the bottom?
   a. \( mgh \)
   b. \( mgh-F \)
   c. \( mgh-Fh \)
   d. \( mgh+Fh \)

3. A truck pulls a trailer with a constant force of 300 newtons at an angle of 20° above the horizontal over a distance of 2 km. How much work was done on the trailer?
   a. 564,000 J
   b. 564 J
   c. 600,000 J
   d. 205,000 J

Use the following diagram and situation to answer questions 4 and 5:

A block is attached to a spring and both are resting on a frictionless table. The block is pulled so that the spring is extended .6 m from equilibrium. Point B is the point of equilibrium.
4. How what is the maximum distance the spring will be compressed if the block is released from rest?
   a. 0 m
   b. 0.77 m
   c. 0.6 m
   d. Not enough information

5. At what point will the block have the greatest velocity?
   a. A
   b. B
   c. C
   d. Not enough information

6. A child pushes a box of mass $m$ at a constant velocity $v$ across a horizontal floor. The coefficient of kinetic friction between the floor and box is $\mu$. How much power does the child use to move the box?
   a. $mgv$
   b. $\mu mgv$
   c. $\mu mgv^2$
   d. $\mu mg v$

7. A 50 kg gym student climbs a 10 m rope in 22 seconds. How much power does he use to do so?
   a. 227 W
   b. 110,000 W
   c. 110 W
   d. 22.7 W

8. A cannonball falls from a height of 22 m. What is its velocity when it hits the ground?
   a. 220 m/s
   b. 14.8 m/s
   c. 6.63 m/s
   d. 21.0 m/s

9. A 6 kg block is released from rest on a semicircular track at a height of 3 m as shown. Friction does 60 Joules of work on the block. How high does the block reach on the other side?

   a. 3.0 m
   b. 0.5 m
   c. 2.0 m
10. A toy gun uses a spring with a spring constant of $k=50$ N/m. If it gets compressed .5 m, how high in the air can it shoot a .05 kg projectile?
   a. 6.25 m  
   b. 25.0 m  
   c. 12.5 m  
   d. 50.0 m

11. A block of mass $m$ is attached to a spring with a spring constant $k$ and the spring is extended horizontally 40 cm. The block is released from rest. What is the block’s velocity as it passes the equilibrium point?
   a. $0.4\sqrt{\frac{k}{m}}$  
   b. $0.4\sqrt{\frac{k}{m}}$  
   c. $0.4k\sqrt{m}$  
   d. $0.4\sqrt{k}$

12. A 2 kg rock and an 8 kg rock are rolling with the same kinetic energy. The 8 kg rock has a velocity of 7 m/s. How fast is the 2 kg rock rolling?
   a. 28 m/s  
   b. 14 m/s  
   c. 7 m/s  
   d. 56 m/s

13. A 65 kg baseball player dives for a base with a velocity of 4 m/s. If the coefficient of kinetic friction between him and the ground is 0.4, what is the farthest he can dive from to still reach the base?
   a. 2 m  
   b. 4 m  
   c. 1 m  
   d. 2.5 m

14. A 5 kg ball attached to a string is spun around it a horizontal circle of radius 1 m at a velocity of 3 m/s. The string keeps the ball in circular motion. How much work does the string do on the ball in one rotation?
   a. 45 J  
   b. $90\pi$ J  
   c. $45\pi$ J  
   d. 0 J

15. A pole-vaulter runs with a velocity of 8 m/s. Neglecting any spring energy added by the pole, what is the maximum height the pole-vaulter can attain?
   a. 3.2 m  
   b. 2.6 m  
   c. 6.4 m  
   d. 5.2 m
Open Ended (2 questions x 30, 25 points approx. 30 minutes)

1. A spring loaded cannon launches a 10 kg cannonball at an angle. The spring in the cannon has a spring constant of $k=300 \text{ N/m}$ and is compressed 1.5 m to start.
   a. How much spring potential energy does the ball have to start?

   b. What is the cannonball’s velocity when it leaves the cannon?

   c. How much work did the spring do on the cannonball?

   d. At the cannonball’s peak, it has a kinetic energy of 20 J. How much potential energy does it have?

   e. At this point, what is its vertical height above where it was fired from?
f. If the cannon was pointed straight upwards, how high would the cannonball go?

2. A 2 kg ball is hanging from the end of a cord. It is hit and rises a vertical height of 2.4 m

   ![Diagram of a ball swinging on a cord]

a. What is the maximum potential energy of the ball?

b. What initial speed was the ball hit with?

c. What was the ball’s kinetic energy after being hit?

d. If air resistance removes 20% of the ball’s energy on the way down, how high up will the ball swing on the other side?

e. If the initial velocity was cut in half, by what factor would the maximum height change?
Multiple Choice (15 questions x 4 points each, approx. 30 minutes)

1. A ball of mass $m$ rolls at a wall at an angle $\theta$ and bounces back with the same magnitude of velocity that it started with, $v$. What is the ball’s total change in momentum?
   a. 0
   b. $mv$
   c. $2mv$
   d. $2mvcos\theta$

2. A cart with an open top is rolling without frictional loss in the rain. As it moves, rain accumulates inside of it. The speed of the cart will:
   a. Increase because of conservation of momentum
   b. Increase because of conservation of energy
   c. Decrease because of conservation of momentum
   d. Decrease because of conservation of energy

3. A baseball player hits a 0.2 kg baseball that has a velocity of 20 m/s and its velocity becomes 31 m/s in the opposite direction. The collision took 25 milliseconds. What is the average force exerted by the bat on the ball during the collision?
   a. 408 N
   b. 88 N
   c. 102 N
   d. 176 N

4. A moving cart has a kinetic energy of 150 J and a momentum of 60 kg⋅m/s. What is its mass?
   a. 3 kg
   b. 6 kg
   c. 9 kg
   d. 12 kg
5. A car moving a certain velocity collides into a car initially at rest and they stick together. Can kinetic energy be conserved in this collision?
   a. Yes, if the moving car is more massive than the stationary car
   b. Yes, if the stationary car is more massive than the moving car
   c. Yes, if the cars have the same mass
   d. No

6. A 55 kg ice skater moving at 4 m/s picks up her 45 kg partner who is moving at 2 m/s in the same direction. What is their final velocity?
   a. 3.0 m/s
   b. 2.0 m/s
   c. 6.0 m/s
   d. 1.5 m/s

7. A 2 kg ball moving at a rate of 3 m/s to the right hits a 3 kg ball initially at rest. After the collision, the heavier ball has a velocity of 2.4 m/s to the right and the lighter ball has a velocity of 0.6 m/s to the left. What kind of collision was this?
   a. Elastic
   b. Inelastic
   c. Perfectly inelastic
   d. Impossible to determine

8. A white ball and a black ball are dropped from the same height. They have the same mass. The black ball bounces higher than the white ball. The impulse applied to the black ball by the floor is:
   a. Less than the impulse applied to the white ball
   b. Greater than the impulse applied to the white ball
   c. Equal to the impulse applied to the white ball
   d. Impossible to determine

9. This graph shows force versus time of a 5 kg ball rolling into a wall. Determine magnitude of the change in velocity of the ball.
   a. 5000 m/s
   b. 5 m/s
   c. 2500 m/s
   d. 2.5 m/s

10. A 0.1 kg golf ball is resting on top of an 8 kg bowling ball. The system is dropped and the velocity of the system is 4 m/s right before it hits the ground. After hitting the ground, the
bowling ball doesn’t bounce at all. What is the velocity of the golf ball right after hitting the ground?

a. 168 m/s
b. 16.8 m/s
c. 324 m/s
d. 32.4 m/s

11. A 7 kg cart moving at a rate of 4 m/s to the right collides inelastically with a 3 kg cart moving at a rate of 1 m/s to the right. After the collision, the 3 kg cart has a velocity of 3 m/s to the right. What is the final velocity of the 7 kg cart?

a. 2.6 m/s
b. 1.9 m/s
c. 3.1 m/s
d. 4.0 m/s

12. An object that has momentum must also have:

a. Impulse
b. Kinetic Energy
c. Acceleration
d. All of the above

13. A 10 kg block at rest with a cherry bomb inside explodes into two pieces. A 6 kg piece flies off to the right with a velocity of 20 m/s. The other piece flies off to the left. How fast is it travelling?

a. 30 m/s
b. 20 m/s
c. 15 m/s
d. 10 m/s

14. A 0.08 kg dragonfly is hovering in the air. A .02 kg drop of sap falls onto the dragonfly and they fall downwards with a velocity of 1.2 m/s. How fast was the sap travelling?

a. 2 m/s
b. 3 m/s
c. 4 m/s
d. 6 m/s

15. A railroad car of mass \( m \) travelling at velocity \( v \) collides with a stationary car of mass \( M \) and the cars couple together. What is their velocity after the collision?

a. \( v/M \)
b. \( mv/(m+M) \)
c. \( v/2 \)
d. \( mv/M \)

**Extra Credit (5 points):** Describe the historical significance of Hank Thompson

**Open Ended (2 questions x 20 points, approx. 35 minutes)**
1. A 500 kg car travelling east at a velocity of 15 m/s collides perfectly inelastically with an 800 kg car travelling north with a velocity of 8 m/s
   a. Qualitatively describe what will happen after the two cars collide

   b. What will be the velocity (magnitude and direction) of the system after the collision?

   c. How much kinetic energy was lost during the collision?

   d. One car is equipped with airbags and seatbelts and the other isn’t. Describe why the car with airbags and seatbelts is safer to be in.
2. A 0.15 kg bullet is fired at a velocity of 45 m/s into a 4 kg wooden block suspended from two strings and becomes embedded within it.

   \[ \rightarrow \]
   \[ \text{Block} \]

   a. What kind of collision is this?
   
   b. Determine the velocity of the system after the collision.
   
   c. How high up does the block swing?
   
   d. The collision took 0.015 seconds. What is the average force exerted on the bullet by the block during the collision?
Exam #6
Fluids

Name______________________________                                                    Date_____________

This is a 60 minute exam that will cover the entire unit of Fluids. The score is out of 100 points.
Partial credit can be earned on open ended questions. Your resources are a calculator and the given
equation sheet. Round all answers to the correct amount of significant figures. Knowledge of topics
from previous units is assumed. Assume g=10m/s^2.

Multiple Choice (10 questions x 4 points each, approx. 30 minutes)

The following object is used for questions 1 and 2:

![Diagram of a cube with dimensions 50 cm x 40 cm x 30 cm]

1. The object is underwater at a depth of 5 meters. The **pressure** on the block is greatest when
which sided is facing upwards?
   a. A  
   b. B  
   c. C  
   d. All sides are equal

2. The object is underwater at a depth of 5 meters. The **force** on the block is greatest when which
sided is facing upwards?
   a. A  
   b. B  
   c. C  
   d. All sides are equal

3. In the following U-tube, the fluid that has a height of 36 cm is water. What is the density of the
other fluid?

![Diagram of a U-tube with heights 36 cm and 28 cm]
a. 778 kg/m³  
b. 1286 kg/m³  
c. 1314 kg/m³  
d. 654 kg/m³

4. A rock is thrown into a pool of water. The pool is in thermal equilibrium. Which of the following must be true?
   a. There is no buoyant force acting on it  
   b. The buoyant force increases as the rock sinks deeper  
   c. The buoyant force decreases as the rock sinks deeper  
   d. The buoyant force remains the same as it sinks

5. A horizontal pipe has an cross-sectional area $A_1$ and velocity $v_1$. At a later point the area changes to $A_2$. If $A_2$ is less than $A_1$, compare $v_1$ to $v_2$.
   a. $v_1>v_2$  
   b. $v_1<v_2$  
   c. $v_1=v_2$  
   d. Impossible to determine

6. How does the volume flow rate at point 1 compare to the volume flow rate at point 2 in the scenario in question 5?
   a. $(V/t)_1>(V/t)_2$  
   b. $(V/t)_1<(V/t)_2$  
   c. $(V/t)_1=(V/t)_2$  
   d. Impossible to determine

7. An ideal gas in a closed container initially has volume $V$, pressure $P$, and Kelvin temperature $T$. If the temperature is changed to $4T$, which of the following pairs of pressure and volume is possible?
   a. $P$ and $V$  
   b. $4P$ and $4V$  
   c. $4P$ and $V$  
   d. $\frac{1}{4}P$ and $V$

8. Two identical glasses are filled to the same level with water. One has ice cubes floating in it. Which glass weighs more?
   a. The one with ice  
   b. The one without ice  
   c. They weigh the same  
   d. Impossible to determine

9. A pump located underground is used to pump water through a pipe with a constant diameter so that the water gets shot out of the ground with a velocity. The pressure at the point of the pump is:
   a. Greater than the pressure at ground level  
   b. Less than the pressure at ground level  
   c. Equal to the pressure at ground level  
   d. 0
10. A raft with a density of 600 kg/m$^3$ and volume of 1.5 m$^3$. What is the maximum amount of weight that can be added to it so that it will still float in water?

   a. 400 kg  
   b. 600 kg  
   c. 800 kg  
   d. 1000 kg

**Extra credit (2 points):** What sport(s) did Mr. Merrill do in college?

**Open Ended (3 questions x 20 points, approx. 50 minutes)**

1. A block with a density of 550 kg/m$^3$ and a volume of 0.45 m$^3$ is completely submerged in water and tied to the bottom of the container as shown:

   ![Diagram of block submerged in water]

   a. Calculate the mass of the block.

   b. Calculate the tension in the string.
c. If the block is located a distance of 0.25 m below the surface of the water, calculate the \textit{total} pressure exerted on the block

d. If the string is cut, what volume of the block will be above the water when it reaches equilibrium? Prove this using a proper method with a free body diagram

2. A fountain is being designed to shoot water out of the ground so it reaches a height of 3 meters. The water is fed with a pipe that has a radius of 0.3 m at the surface of the ground. The pipe leads to a pump that is 2 meters below the ground. The pipe has a radius of 0.5 meters at this point
   a. Calculate the velocity that the water leaves the ground at.

   b. Calculate the velocity at the point where the pump is located.
c. Calculate the volume flow rate of the water in the pipe

d. Calculate the pressure exerted by the pump.

3. A 0.15 m³ container is filled with an ideal gas and fitted with a loose cap. It is heated to a temperature of 110°C and the cap is tightened. It is allowed to cool down to 25°C.
   a. Calculate the Pressure in the container at this point

   b. The cap has a cross sectional area of 0.5 m². Calculate the force exerted on the cap by the gas

   c. A hole is now punched in the top of the cap. Calculate how much gas enters or leaves the container and state whether it enters or leaves.
## Appendix F: Gradebooks

### Quarter 1

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Number of Students: 12
Appendix H: Student Produced Music Video
Appendix I: Teaching and Observation Hours

Totals:

Teaching: 151 hours
Observing: 104 hours
Worcester Polytechnic Institute  
Teacher Certification Program  
Practicum Log

Name: Tylor TIlbe

Week Of: 8/28/13

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Totals  
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### Worcester Polytechnic Institute
### Teacher Certification Program
### Practicum Log

**Name:** Tyler T. Ike

**Week Of:** 7/2/13

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Name: Tyler Tilbe

Week Of: 9/9/13

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Worcester Polytechnic Institute  
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Worcester Polytechnic Institute
Teacher Certification Program
Practicum Log

Name: Tylwe J. H

Week Of: 9/23/13

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Worcester Polytechnic Institute
Teacher Certification Program
Practicum Log

Name: Tyler 

Week Of: 9/30/13

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# Worcester Polytechnic Institute
## Teacher Certification Program
### Practicum Log

**Name:** Tyler Tilbe

**Week Of:** 10/7/13

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Worcester Polytechnic Institute  
Teacher Certification Program  
Practicum Log

Name: Tyler Tilke

Week Of: 10/14/13

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Worcester Polytechnic Institute  
Teacher Certification Program  
Practicum Log

Name: [Tyler Title]  

Week Of: 10/21/13

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Worcester Polytechnic Institute  
Teacher Certification Program  
Practicum Log

Name: **Tyler Tille**

Week Of: **11/18/13**

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Worcester Polytechnic Institute
Teacher Certification Program
Practicum Log

Name: Tyler Title

Week Of: 11/11/15

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Worcester Polytechnic Institute
Teacher Certification Program
Practicum Log

Name: Tyler Tolke

Week Of: 11/18

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Worcester Polytechnic Institute  
Teacher Certification Program  
Practicum Log

Name: Tyler Tilby

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Worcester Polytechnic Institute
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Practicum Log

Name: Tyler Tillis

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Total Direct Hours: 18.75

Observation Hours: 5
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Worcester Polytechnic Institute  
Teacher Certification Program  
Practicum Log

Name: Tyler T. 

Week Of: 12/16/13 

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Works Cited


